PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH.

MAR 25 1935

THE APRIL SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

LABORATORIES IN THE STRATOSPHERE. DR. LYMAN J. BRIGGS 295
STABLE AND UNSTABLE NUCLEI. PROFESSOR RUDOLF W. LADENBURG 307
GREGOR JOHANN MENDEL. D. J. HARBOU 313
DETERMINING PARENTAGE. DR. ALEXANDER S. WIENER 323
WINTER INJURIES AMONG TREES AND SHRUBS. JOHN G. JACK 332
MAN MEDDLES WITH NATURE. PROFESSOR HARLEY J. VAN CLEAVE 339
WHAT PREVENTS SOCIAL PROGRESS? PROFESSOR DWIGHT SANDERSON 349
SCIENCE SERVICE RADIO TALKS:
THE ASTRONOMY OF NAVIGATION. DR. LORING B. ANDREWS 360
MAPPING FROM THE AIR. PROFESSOR S. S. STEINBERG 363
WHEN THE PAST BROKE ITS SILENCE. DR. E. A. SPEISER 366
INTERPRETING SCIENCE TO THE PUBLIC. L. N. DIAMOND 370
LETTERS OF ALFRED RUSSEL WALLACE TO LESTER F. WARD. DR. BERNHARD J. STERN 375
THE PROGRESS OF SCIENCE:
David White, An Appreciation; Dr. Isaiah Bowman, President of the Johns Hopkins University; Professor Charles A. Kraus, Willard Gibbs Medalist; The New Medical Buildings at Yale University 380

THE SCIENCE PRESS
LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

NEW BOOKS OF SCIENTIFIC INTEREST

The Diffraction of Light, X-Rays, and Material Particles. C. F. MEYER. xiv + 473 pp. Illustrated. $5.00. Chicago.

An introductory treatment of diffraction beginning with its discovery in the seventeenth century, including the principal observational phenomena together with the theory which accounts for them. The subject is developed reasonably far without the aid of extensive mathematics.

Experimental Physics. G. F. C. SEARLE. xiv + 363 pp. $4.50. Cambridge.

An advanced laboratory manual containing experiments in mechanics, elasticity, surface tension, viscosity, heat and sound, continuing the material which the author omitted from his three earlier manuals in experimental physics. He is a lecturer and demonstrator in experimental physics at Cambridge University.

New Pathways in Science. SIR ARTHUR EDDINGTON. x + 332 pp. Illustrated. $3.00. Macmillan.

In this volume the English astronomer-philosopher surveys many aspects of the physical world from the point of view of an experimental philosopher. Except for two chapters, the material was first presented as the Messenger Lectures at Cornell University.

Men, Mirrors, and Stars. G. E. PENDRAY. x + 339 pp. Illustrated. $3.00. Funk and Wagnalls.

A popular history of telescopes and general outline of astronomy. The author describes for the layman the progress of astronomy from the days when the ancients looked at stars without instruments, through the ages down to and including recent astronomical discoveries.

Physical and Dynamical Meteorology. D. BRUNT. xxii + 411 pp. Illustrated. $7.00. Macmillan.

This treatise on physical meteorology has been prepared primarily as a textbook for postgraduate students. It is devoted chiefly to theoretical meteorology and emphasizes the physical aspects of the subject. The author is professor of meteorology at the University of London.

A Manual of Biochemistry. J. F. MCCLENDON. vii + 381 pp. Illustrated. $5.00. Wiley.

A textbook in biochemistry consisting of the following parts: Introduction; Inorganic; Organic; Physiological Summary; Laboratory work and finally a thirty-four page table giving the biochemical properties of one thousand substances. The author is professor of physiological chemistry at the University of Minnesota Medical School.

The Structure and Reproduction of the Algae. F. E. FRITSCH. Volume I. xvii + 791 pp. Illustrated. $8.00. Macmillan.

A treatise on the morphology of algae whose purpose is to serve as an introduction to their study for the university student and research worker. The treatment is primarily morphological and taxonomic, and biological problems are discussed only when they are thought to have a bearing on morphology.

A History of Embryology. J. NEEDHAM. xviii + 274 pp. Illustrated. $4.00. Cambridge.

This treatise which is based upon chapters from an earlier monograph by the author on chemical embryology is divided into the following parts: Embryology in Antiquity; Embryology from Galen to the Renaissance; Embryology in the Seventeenth Century; Embryology in the Eighteenth Century.

Biology for Everyman. The Late SIR J. ARTHUR THOMSON. Edited by E. J. Holmyard. Two volumes. viii + 1561 pp. Illustrated. $5.00. Dutton.

A survey of the whole field of biology for the layman. The first volume is devoted to the animal world. In the second volume the author considers animal life in general, the plant world, and man.

Confession of a Scientist. R. L. DITMARS. xii + 241 pp. Illustrated. $3.50. Macmillan.

A record of some of the intimate details that enter into the work of a naturalist. Dr. Ditmars describes his varied adventures with reptiles in the field, the zoo and on the lecture platform. He tells in detail his experiences in capturing and caring for a vampire bat.

The Child. F. B. SHERBON. xix + 707 pp. Illustrated. $3.50. McGraw-Hill.

A study of the origin, development and care of the child. The book endeavors to present the "whole child" from his earliest origins until the age of five years, and in so doing draws continually upon the sciences of biology, biochemistry and psychology.

Psychology and Health. H. BANISTER. viii + 256 pp. $2.50. Macmillan.

The purpose of this volume is to help medical students and practitioners understand the workings of the human mind. The author emphasizes the importance of psychology as a link between doctor and patient as well as its influence on the healthy and diseased.

The Search for the Northwest Passage. N. M. CROUSE. 533 pp. Illustrated. $4.00. Columbia.

The first part of this book is devoted to the preliminary voyages in search of the Northwest Passage. Each of the dozen or more succeeding attempts of Arctic navigators to penetrate the ice barriers is related in narrative form, including the successful voyage of Amundsen in 1905.

Race Relations. W. D. WEATHERFORD and C. S. JOHNSON. x + 590 pp. $3.20. Heath.

A textbook in sociology which attempts to work out a basis for intelligent and mutually tolerant relations between the white man and the negro; both races being represented by the co-authors of this book. Each expresses his views in chapters which are initialed in the table of contents.

THE SCIENTIFIC MONTHLY

APRIL, 1935

LABORATORIES IN THE STRATOSPHERE

By Dr. LYMAN J. BRIGGS

DIRECTOR, NATIONAL BUREAU OF STANDARDS; CHAIRMAN, SCIENTIFIC ADVISORY COMMITTEE OF THE NATIONAL GEOGRAPHIC SOCIETY—ARMY AIR CORPS STRATOSPHERE EXPEDITION

THE conquest of the upper air has written a most interesting chapter into the story of human endeavor. Over thirty years ago two German pilots, in the open basket of a balloon, reached the unprecedented altitude of 35,420 feet. Men can not live long at such altitudes without an extra oxygen supply, and these daring pilots barely escaped with their lives. Their feat remained unchallenged for more than twenty years.

But the development of the airplane, together with the oxygen mask, opened up a new line of attack, and in 1923 Lecointe of France climbed to a height of 36,550 feet. Since that time, the altitude record for airplanes has passed in succession to the United States, Germany, the United States, England, France and Italy, where last year Donati climbed to the astonishing height of 47,350 feet.

In 1927 Captain Gray, of the United States Army, made a valiant attempt to bring the title back to the balloonists. Twice during that year Gray reached an altitude of 42,470 feet, which exceeded all airplane records up to that time. On the first flight he was obliged to make a parachute jump, and after the second flight he was found dead in the basket of his balloon, his oxygen supply having failed. Unhappily, neither of these flights could be officially credited, because under the rules of the game the pilot must land his craft safely.

With Auguste Piccard's invention and successful use of an airtight gondola in a balloon flight in 1931, the whole picture once more was changed. The gondola is closed while the air pressure is still relatively high, and the carbon dioxide exhaled by the occupants is absorbed by chemicals. The balloonists are free to move about while making their observations, and the gondola protects them to a considerable extent from the intense cold. The altitude reached no longer depends upon the fortitude of the pilots, but is determined by the size of the balloon.

In his first flight in 1931, Piccard reached an altitude of 51,775 feet, thus eclipsing by more than 4,000 feet the highest altitude ever attained in an airplane. In 1932 he made a second flight to a height of 53,150 feet. Since that achievement, six stratosphere flights have been made, two in Russia, one in Belgium and three in America. The present record is held by Commander Settle and Captain Fordney, who in their *Century of Progress* balloon in 1933 reached an altitude of 61,237 feet.

In the intense sunlight of the stratosphere the gas in the balloon becomes heated far above the temperature of the surrounding air. When the balloon descends, this superheat is gradually lost and the buoyant gas diminishes in volume. The lift decreases, just as if gas had actually been discharged from

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

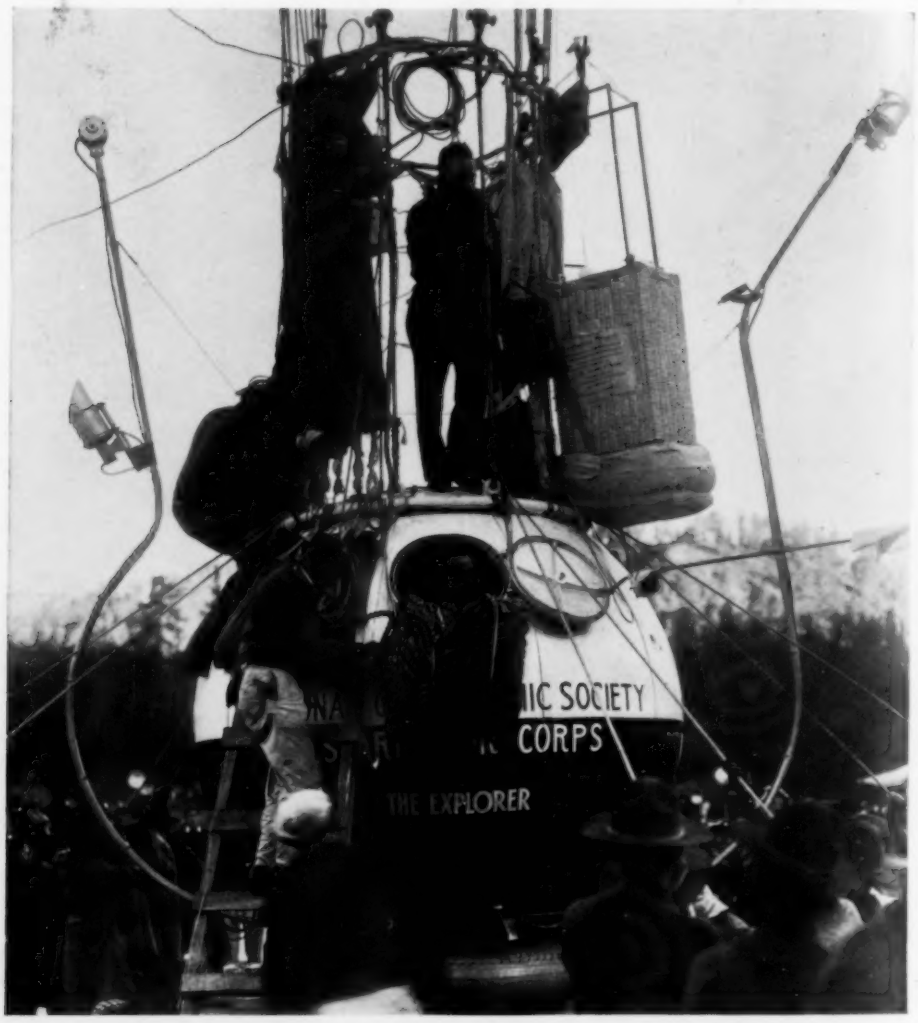
THE STRATOCAMP IN THE BOTTOM OF THE BOWL

THE GREAT BALLOON IS STORED IN ITS BOX IN THE CENTER OF THE CIRCULAR RING. THE GONDOLA IS SEEN ON ITS TRUCK BETWEEN THE BALLOON AND THE CABIN. THREE ROWS OF HYDROGEN CYLINDERS ARE PILED AT THE LEFT AND THE CAMP TENTS ARE IN THE BACKGROUND.

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight
THE BEGINNING OF THE INFLATION

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight
THE INFLATION PROCEEDS

AND THE CABIN. THREE BOWS OF HYDROGEN CYLINDERS ARE FILLED AT THE LEFT AND THE CAMP TESTS ARE IN THE BACKGROUND.



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

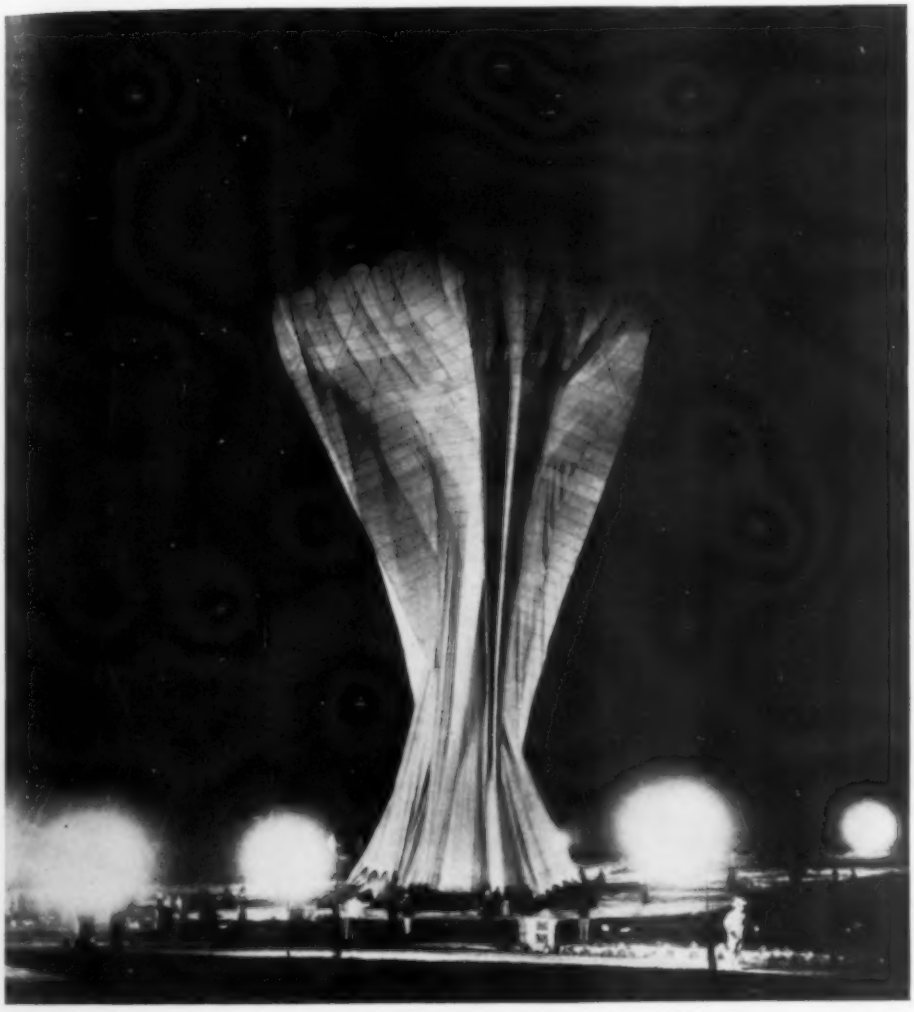
ABOUT READY TO GO.

THE LARGE SPECTROGRAPH IS IN ITS BASKET ON TOP OF THE GONDOLA. THE LIFTED ARMS CARRY THE ELECTRICAL THERMOMETERS AND THE FAN FOR TURNING THE BALLOON. MAJOR KEPNER STANDS ON TOP OF THE GONDOLA AND CAPTAIN STEVENS CAN BE SEEN THROUGH THE PORTHOLE.

the balloon. Unless a generous supply of ballast is kept in reserve at the highest point of the flight a dangerously rapid descent can not be checked.

Records recovered from the wreckage of the ill-fated Russian balloon indicated that it attained the astounding altitude of 72,000 feet. But the unfortunate Russian pilots, in their desire to gain altitude, failed to reserve sufficient ballast to check the rapid descent of their balloon, and all of them were killed.

While altitude records alone are of no great significance, they do provide a significant measure of accomplishment in the development of engines, airplanes and balloons, which can be utilized in undertakings of real importance. An



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE INFLATION IS COMPLETED

AND THE GUY ROPES ARE BEING PAYED OUT SO THAT THE GONDOLA CAN BE BROUGHT UNDER THE BALLOON.

altitude record was not the primary objective of any of the eight stratosphere flights I have mentioned. In each case scientific equipment was carried for the purpose of wresting from nature some of the secrets which are denied to us because of the blanket of air surrounding the earth. To discover them we must rise above this air blanket, putting as much of the atmosphere below us as possible.

The 1934 expedition of the balloon *Explorer*, under the joint sponsorship of the National Geographic Society and the Army Air Corps, was a further step in this direction. The purpose was to carry into the stratosphere substantial apparatus such as would be used for the

making of precise measurements in a laboratory on the ground if the blanketing atmosphere did not intervene. This apparatus weighed more than a ton. It was a load which no other balloon had ever been called upon to carry.

The gondola of the *Explorer* was in fact a floating laboratory. And to carry its great weight up into the extremely tenuous stratosphere, where the air pressure was less than one fifteenth that at sea-level, it was necessary to build a balloon far larger than had ever been built before. Auguste Piccard's balloon had a capacity of 500,000 cubic feet; the *Century of Progress* balloon, flown again last year by Dr. and Mrs. Jean Piccard, 600,000 cubic feet. The volume of the Russian balloon was about 900,000 cubic feet. The *Explorer* was a spherical balloon 179 feet in diameter, with a capacity of 3,000,000 cubic feet.

The advisory committee charged with the task of planning the scientific program received so many suggestions regarding desirable stratosphere observations that even with the remarkable facilities at hand much choosing was necessary. One of the main problems proved to be the discarding of investigations which could not be carried out within the space and weight limitations of the gondola.

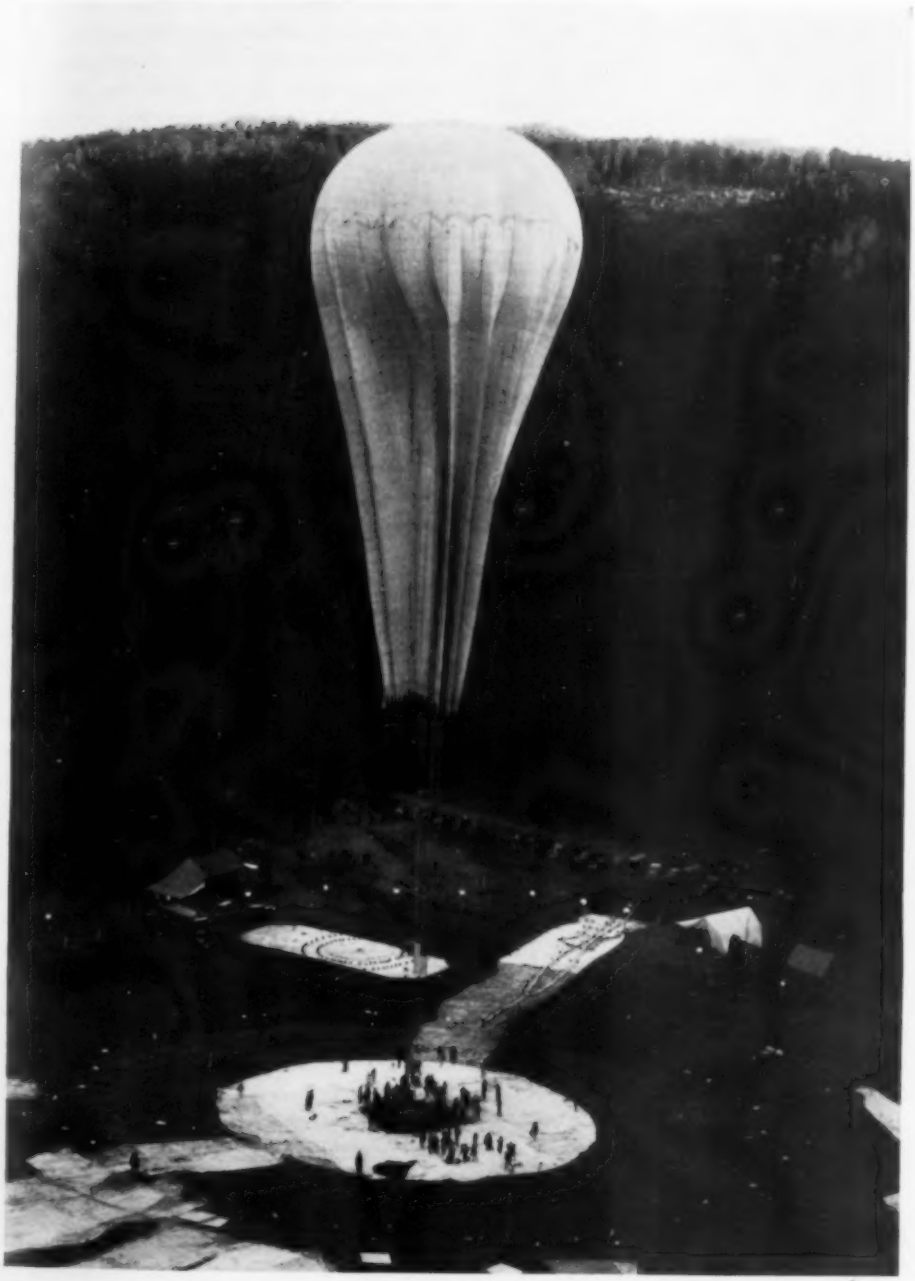
The scientific program centered broadly on four objectives: (1) the study of the intensity and direction of cosmic radiation at high altitudes; (2) the determination of the position and distribution of the ozone layer in the stratosphere; (3) the composition of air samples collected in the stratosphere; and (4) the comparison of altitude determined from photographs of surveyed country below the balloon with the altitude computed from the pressure and temperature of the air at the instant the photograph was made.

The apparatus included three electroscopes for studying the change in intensity of cosmic rays, provided by Dr. Millikan and Dr. Neher, of the California Institute of Technology. One of these electroscopes was surrounded by a massive shield consisting of 600 pounds of lead shot, so arranged that it could be drawn off quickly and used as ballast if necessary. The second electroscope was shielded by 200 pounds of shot, while the third was left bare, accessible even to the mildest cosmic radiation.

Dr. Swann and Dr. Locher, of the Bartol Research Foundation, Franklin Institute, installed eight cosmic ray "telescopes" for studying the direction of the cosmic radiation. Two were placed horizontally, two vertically, while the others were fixed at intermediate angles of thirty and sixty degrees, all the instruments being located in the same vertical plane. This made it possible to count the rays coming in from the direction in which the telescopes were pointed and actually to sweep the heavens by turning the gondola about a vertical axis. Captain Stevens provided for this by mounting a small motor with a propeller at the end of a long arm projecting out horizontally from the gondola. In this way the great balloon could be slowly turned at will in either direction or kept oriented in any desired position.

The spectrographic equipment for studying the position and distribution of the ozone layer was supplied by Dr. O'Brien, of the University of Rochester, and by the Bausch and Lomb Optical Company. Two of the spectrographs were carried inside the gondola, while the third was suspended on a rope 500 feet below, so as to be out of the shadow of the balloon at all times. Other instruments included those for measuring the temperature and the pressure of the outside air, while in the top of the gondola were the large evacuated flasks for securing air samples from the stratosphere.

During the inflation and launching of



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

ATTACHING THE GONDOLA TO THE BALLOON

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

GOING UP.

ELEVATION ABOUT 15,000 FEET. SPECTROGRAPH WITH ITS PARACHUTE HAS BEEN LET DOWN BELOW THE GONDOLA.

a balloon as large as the *Explorer* the air must be still. The great bag would be wholly unmanageable in a wind. After much searching, a natural bowl in the Black Hills near Rapid City, South Dakota, was selected by Major Kepner as the site of the take-off. This bowl is nearly surrounded by cliffs and hills four to five hundred feet high, affording the needed protection from winds which might arise during the inflation. Since it was expected that the balloon would drift several hundred miles to the east or southeast, this location seemed also to insure a landing in open prairie country, where the balloon would not be subject to damage by alighting in a forest.

I have never seen a more remarkable example of cooperation for scientific objectives than that which sprang into action upon the selection of the site for the Stratocamp. With the National Geographic Society generously sponsoring the flight, footing the bills and making the enterprise possible, the Army Air Corps provided flight personnel of outstanding experience, and also assigned two airplanes with personnel for the use of the expedition. Through the courtesy of the officers of Fort Meade, a military camp was established in the bowl, which provided guards, mess equipment, a hospital unit and tent facilities for the scientific staff. A road was built into the bowl by state and local officials, Rapid City provided a fire engine with personnel for additional fire protection, and the South Dakota National Guard transported the cylinders of hydrogen. The American Telegraph and Telephone Company contributed telegraph lines and instruments necessary for the weather service. Experienced men detailed by the U. S. Weather Bureau and the U. S. Signal Corps prepared two weather maps at the camp each day as suitable conditions for the flight were anxiously awaited. The National Broadcasting Company installed in the gon-

dola the special transmitting and receiving equipment, providing dependable communication between gondola and ground.

Finally on July 27, 1934, the weather map indicated the favorable conditions so long awaited. Clear weather was promised to the east for the following day, with no thunderstorms indicated and low wind velocities probable at the camp.

The great balloon was taken out of its box, where it had been stored for more than six weeks, and placed on a canvas-covered space that had been prepared for it. The upper part was carefully unfolded or "blossomed out" into a circular disk about a hundred feet in diameter. Canvas tubes were run from the balloon to the hydrogen supply stored in over a thousand heavy-walled cylinders, each under a pressure of 2,000 pounds per square inch. At eight o'clock in the evening the inflation was begun, and by midnight it was completed, with something over 200,000 cubic feet of hydrogen in the big bag. Floodlights surrounding the field made it possible to carry on all necessary operations without difficulty.

Balloons which travel at relatively low altitudes are completely filled with gas when they leave the ground. This would be wasteful of hydrogen in the case of a stratosphere balloon, because the hydrogen would be constantly expanding and flowing out of the bag as the balloon rose to levels where the air is less dense. The *Explorer* therefore was inflated to only about 7° per cent. of its total capacity, enough to fill the bag 100 per cent. at an altitude of 65,000 feet, from which point upward hydrogen would flow out continuously through the appendix.

The shape of the partially filled balloon at take-off resembled a gigantic exclamation point, with the hydrogen gas rounding out the top and the gondola forming the dot below. When the inflation was completed, the thirty-six mooring ropes holding the great bag to the earth were gradually slackened

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

COMING DOWN

FROM A MAXIMUM ELEVATION OF 62,000 FEET. BOTTOM FABRIC HAS DROPPED BELOW THE CATENARY BAND TO WHICH THE ROPES SUPPORTING THE GONDOLA ARE ATTACHED. NORTH PLATTE RIVER IN BACKGROUND.

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE BOTTOM TEARS AWAY.

NOTE THE CHANGE IN SHAPE OF THE BALLOON.

away, and the gondola with its load of carefully tested instruments, ballast and accessories, was wheeled out on its special car and attached to the balloon. Major Kepner, Captain Stevens and Captain Anderson climbed aboard. The ballast was adjusted to give the desired lift, and as the sun began to light the peaks of the adjacent hills Major Kepner gave the word to let go. From the rim of the bowl a great cheer went up from the twenty thousand people who had gathered to see the great balloon rise silently, gracefully, majestically out of the bowl.

The plan was to stop at 40,000 feet, and again at 60,000 feet for observations, and then to go on up to the ceiling of the balloon. The stop at 40,000 feet was made according to schedule, and the pilots then proceeded to the 60,000 foot level. The balloon was now nearly full, and in looking up at it through a window in the top of the gondola, they noticed several tears in the bottom of the bag. That was the first indication of trouble.

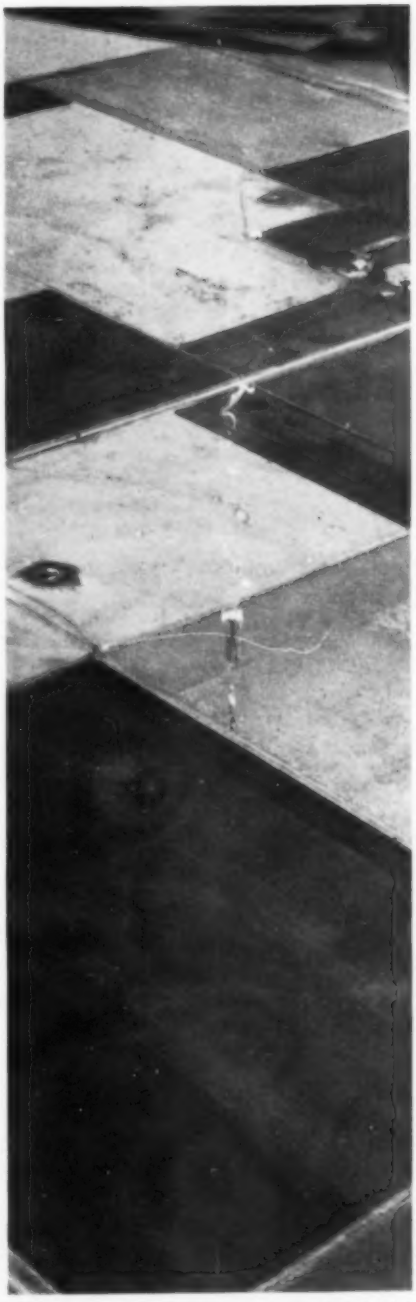
A new method of folding the balloon for storage had been used to facilitate handling during inflation, the lower part being inverted and tucked up into the main body of the bag. It was believed that as the balloon expanded this tucked-up fabric would gradually drop to its normal position. After the crash it was found that during the long period of waiting for favorable weather, this lower part had become stuck or pasted, so to speak, over folds in the main body of the balloon, so that, when the balloon filled and these folds were forced open by the expanding gas, the bottom fabric was torn.

After spending about half an hour at the 60,000 foot level, the balloon began a gradual descent. At 18,000 feet the gondola was opened and the men climbed out on the top with their parachutes to inspect the damage to the balloon. The

tears had increased in size, and as the descent continued the entire bottom of the bag began to tear away, and finally dropped down on the gondola. It was then possible to look directly up into the balloon, which had now become in effect a parachute partly filled with hydrogen gas, which was rapidly mixing with air to form an explosive mixture. At an elevation of about 3,000 feet an explosion occurred, and the entire top of the balloon was torn away. The gondola now had nothing to support it, and was falling like a plummet. In less than twenty-five seconds the men had taken safely to their parachutes and the gondola with its load of instruments had crashed in a Nebraska corn field.

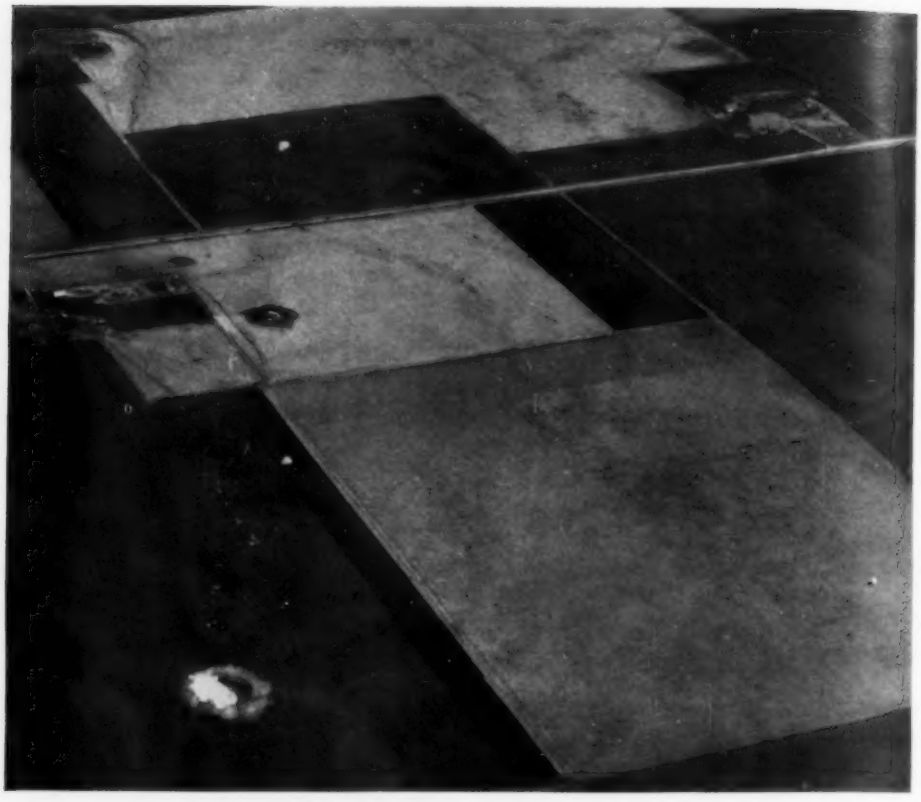
From the scientific standpoint the flight at first seemed a complete failure, for the records were taken on photographic films which were broken open and exposed to broad daylight amidst the wreckage of the gondola. But when films which remained tightly wound on their spools were developed the greater part proved to be still in good condition even when outer edges were badly fogged. Even the photographs made with the vertical camera to determine altitudes, which at first were thought hopelessly fogged, were found legible up to the highest altitude attained. The suspended spectrograph had been cut loose before the explosion occurred and landed safely on its own parachute. It was still busily taking records when recovered. And so a much larger part of the records was salvaged than the most optimistic of us thought possible immediately after the crash. The results of the scientific observations, together with a full account of the flight, and a detailed study of the cause of the failure of the balloon will be given in a special publication on the flight of the *Explorer* which will shortly be issued by the National Geographic Society.

Undaunted by the loss of the balloon,



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE BALLOON EXPLODES
AND THE GONDOLA FALLS LIKE A PLUMMET.



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE END OF THE EXPLORER.

MAJOR KEPNER AND CAPTAIN STEVENS ARE ABOUT TO LAND IN THEIR PARACHUTES. THE SUSPENDED SPECTROGRAPH WHICH HAD BEEN CUT LOOSE BEFORE THE EXPLOSION OCCURRED CAN BE SEEN WITH ITS PARACHUTE SOME DISTANCE TO THE RIGHT IN THE ADJACENT FIELD.

the National Geographic Society and the Army Air Corps are busily planning another flight for the coming summer. The construction of the balloon, the gondola and the instruments is already under way, and the experience gained during the first flight is being fully utilized. As additional safety precautions, the cap of the balloon and the bottom will be made of somewhat heavier fabric and, most important of all, the balloon will be inflated with helium instead of hydrogen, eliminating all possible danger of explosion. To offset the added weight of the balloon and the use of helium, which is less buoyant than hydrogen, the new balloon will be made somewhat larger, with a capacity of about 3,700,000 cubic feet. It is planned to make the second ascent from the same bowl in the Black Hills of South Dakota.

The award of the Distinguished Flying Cross of the United States Army to the three brave men who made the flight has given the deepest satisfaction to every one associated with the expedition. While Major Kepner has been detailed to other duties which will keep him from participating in the coming flight, Captain Stevens and Captain Anderson are now preparing to take the new laboratory into the stratosphere.

STABLE AND UNSTABLE NUCLEI

By Dr. RUDOLF W. LADENBURG

BRACKETT RESEARCH PROFESSOR OF PHYSICS, PRINCETON UNIVERSITY

Two years ago when I reported in this journal on the fundamental units of the physical world,[1] I had to end with the question: What are those fundamental units? At that time had just been discovered the positive electron, the real counterpart of the negative electron, probably having the same small mass and the same elementary charge, but with the positive sign, and a beginning had been made in the study of the properties of the neutron, the uncharged particle of about the mass of the hydrogen atom. The question was: Are these all elementary particles? Or is the neutron perhaps a combination of the proton (that is the nucleus of the hydrogen atom) and of a negative electron—or is the proton a complex particle, composed of a neutron plus a positive electron?

To-day there is no definite answer to this question—but perhaps the question has lost its sense. We know the building stones of the atoms. They consist of positively charged heavy nuclei surrounded by the light negative electrons. We know the arrangement of these electrons in the different atoms, but we are just beginning to learn something about the nucleus. The radioactive phenomena, the emission of alpha, beta and gamma rays, the transmutation of elements—all these are processes due to the nuclei.

We know further that one of their building stones is certainly the proton, but there ought to be another kind of particles which hold the protons together—otherwise these would repel each other and there would be no stable nuclei. For a long time it was understood that the negative electrons are the other building stones, but to-day we doubt whether free electrons exist at all in the nuclei. They are certainly ejected by natural and by artificially produced radioactive atoms and appear as "beta particles," but they are no longer thought of as free units in the nuclei. We have important experimental and theoretical reasons for this revolutionary idea. Popularly expressed, the electron is too big for the small nucleus; more exactly, but less clearly: the mass and the momentum of the electron is so small that the corresponding DeBroglie wave has no room in the nucleus. What, then, instead of the electrons, does hold the different protons together? It is the neutrons, according to the modern conceptions of Heisenberg, Wigner and others. In spite of their lack of electric charge, the neutrons are bound by strong attractive forces to the protons when they are very near together. As a matter of fact, the nature of these forces is one of the great problems of to-day, but they certainly exist and are much stronger than the repulsive forces between proton and proton.

The numbers of the particles of these two kinds determine the characteristic constants of the nucleus: the positive charge Z equals P, the number of protons, and the difference between the mass $\overline{M}$ and the charge, $\overline{M} - Z$, equals N, the number of neutrons. $\overline{M}$, which equals $P + N$, is not the exact mass of the atom —it is the nearest whole number, the "mass number," if the unit of mass is 1/16 of that of the oxygen atom. The chemists, especially Berzelius, displayed a deep insight into nature when they chose this unit. Only on account of this

[1] THE SCIENTIFIC MONTHLY, 36: 465–467, May, 1933.

choice is the deviation of the exact mass M from the whole number for all nuclei very small, and only when measured in those units is the number of neutrons given in such a simple way. The knowledge of M gives us not only the number of neutrons but also the energy content of a nucleus: the difference of this mass M from the sum of the masses of protons and neutrons, "the mass defect," is equivalent to the energy set free in the building of the nucleus. The same energy would have to be put into the nucleus in order to overcome the attracting forces between protons and neutrons and break it into single fragments. Einstein's law, the equivalence of mass and energy, determines in this way one of the fundamental properties of the nucleus.

The simplest compound nucleus is that of deuterium, the heavy isotope[2] of hydrogen of mass 2 discovered three years ago by Urey. This nucleus, baptized recently "deuteron," in order to avoid confusion of the older name "deuton" with the "neutron," is abbreviated by the symbol ${}_1^2\mathrm{D}$; the upper index designates its mass, the lower one its charge, as with the symbols ${}_1^1\mathrm{H}$ for the proton and ${}_0^1\mathrm{n}$ for the neutron. The "mass defect" and therefore the binding energy of the deuteron is about 2 million electron volts (eV), as determined from the recent discovery of its disintegration into a proton and a neutron by means of hard gamma-rays of an energy[3]) of 2.6 million eV. The same experiment shows that the mass of the neutron is very nearly the same as that of an hydrogen atom, settling a much-discussed question. This result is of fundamental importance. If the masses of the hydrogen atom and the neutron are equal, then both are energetically stable. If, for example, the neutron were distinctly heavier, it would disintegrate spontaneously into a proton and an electron, for such a process would set free the amount of energy equivalent to the surplus of the mass of the neutron.

The next simple nuclei are ${}_1^3\mathrm{H}$, the third isotope of hydrogen, and ${}_2^3\mathrm{He}$, the isotope of ordinary helium ${}_2^4\mathrm{He}$, both particles discovered only last year in the Cavendish Laboratory by bombarding deuterium with fast-moving deuterons. The two nuclear reactions are

$$ {}_1^2\mathrm{D} + {}_1^2\mathrm{D} \rightarrow {}_2^3\mathrm{H} + {}_1^1\mathrm{H} $$

and

$$ {}_1^2\mathrm{D} + {}_1^2\mathrm{D} \rightarrow {}_2^3\mathrm{H} + {}_0^1\mathrm{n} $$

Knowing the energy of the impinging and produced particles and the masses of ${}_1^2\mathrm{D}$, ${}_1^1\mathrm{H}$ and ${}_0^1\mathrm{n}$, one finds the masses of ${}_1^3\mathrm{H}$ and ${}_2^3\mathrm{He}$ by means of the equivalence between mass and energy. They come out so nearly equal that one could almost expect that ${}_2^3\mathrm{He}$ disintegrates spontaneously into ${}_1^3\mathrm{H}$ with emission of a positive electron. Careful experiments in the Palmer Physical Laboratory have shown that this is not the case; both are stable, their mean lifetime being at least ten million years. The mass difference of ${}_2^3\mathrm{He}$ against ${}_1^2\mathrm{D}$, which has just one proton less, is much smaller than the mass of the proton, showing that the binding of a proton to a deuteron means an energy gain of nearly 5 million eV. In other cases this gain is two or three times larger. The binding energy of the very stable helium nucleus is even 27 million eV. Such enormous energies are stored up in the nuclei. That is why even relatively slow protons of only 30,000 eV when bombarding lithium, for example, are able to split its nucleus into alpha particles—*i.e.*, He nuclei of many million eV. kinetic energy, according to the reaction

$$ {}_3^7\mathrm{Li} + {}_1^1\mathrm{H} \rightarrow {}_2^4\mathrm{He} + {}_2^4\mathrm{He}. $$

In a similar way is the other lithium-

[2] "Isotope" is the name used for atoms of different mass and of the same nuclear charge Z which occupy the same place (τόπος) in the periodic table of the elements.

[3] The energy of a light quantum or a particle is measured by the number of volts which has to be applied to an electron for giving it the same kinetic energy. 1 million eV. corresponds nearly to 1/1000 of our mass units using the Einstein relation between mass and energy.

isotope ^{7}Li split by bombarding deuterons into alpha particles of even higher energy. The exact measurements of the kinetic energies and the nuclear masses involved in these reactions give a most sensitive test of Einstein's equivalence of mass and energy, which is confirmed within one per cent., a surprisingly high accuracy for such delicate experiments.

The kinetic energy of the bombarding particles plays only an unimportant rôle in this energy balance, but it is decisive for the efficiency of the process. The larger this kinetic energy, the greater is the probability for the particles to penetrate the potential barrier surrounding the positively charged lithium nucleus guarding against the approach of the similarly charged H or D particles. As a matter of fact, this barrier is very much higher than their kinetic energy, so that according to our classical mechanical ideas these particles would not be able to penetrate. The modern quantum and wave mechanical conceptions show, however, that for each particle of definite kinetic energy there is a certain probability of leaking through the potential wall and that this probability increases very much with increasing kinetic energy. Once having entered the interior of the nucleus—compare Fig. 1[4]—the impinging particle may be kept there on account of the strong binding forces exerted by the neutrons.

The potential wall around the nuclei increases with increasing charge, therefore the probability of transforming nuclei by accelerated positively charged particles decreases very much with increasing atomic number of the target. The heaviest nucleus thus far transformed in this way is that of the potassium atom.

Fast neutrons on the other hand penetrate nuclei much more easily, in fact there is very probably no potential barrier for neutrons. It seems that the smaller their energy, the better they enter sometimes the nuclei if only they come near enough. So was it even possible to transform the uranium atom, the heaviest of all known atoms, as Fermi and his collaborators showed half a year ago. The phenomena produced by the neutrons are especially interesting: The bombarded nuclei show sometimes "artificial radioactivity," going over first into unstable ones, which then emit mostly negative electrons spontaneously for some time, their mean lifetime being in some cases fractions of seconds, in others many minutes, hours or even days. Also alpha particles of radium are able to produce artificial radioactivity, as was shown by the French couple Curie-Joliot. In this case mostly positive electrons are emitted by the transformed unstable nuclei. How can this production of unstable nuclei be understood? Let us consider Fig. 2, the big table of the nearly 300 stable and radioactive nuclei known to-day. Their atomic number $Z = P$ (the number of protons) is plotted on the horizontal axis, the values of $M - Z = N$, their number of neutrons, on the vertical axis, so that the different isotopes of one element lie vertically below one another. The full circles indicate the most abundant isotope, the open circles the less abundant ones, the crosses the radioactive atoms. This diagram shows many striking regularities which reveal some secrets of the arrangement of protons and neutrons: even numbers of protons and neutrons are very much favoured, elements with odd numbers of Z have never more than one or two isotopes, whereas elements with even numbers of Z have up to 9 or 11 isotopes (compare number 80 (Hg) or 50 (Sn)). This favouring of even numbers has been known for a long time in the relative abundance of the chemical elements in

[4] Fig. 1 is drawn for the case of the aluminium nucleus according to the study of its disintegration by alpha particles.

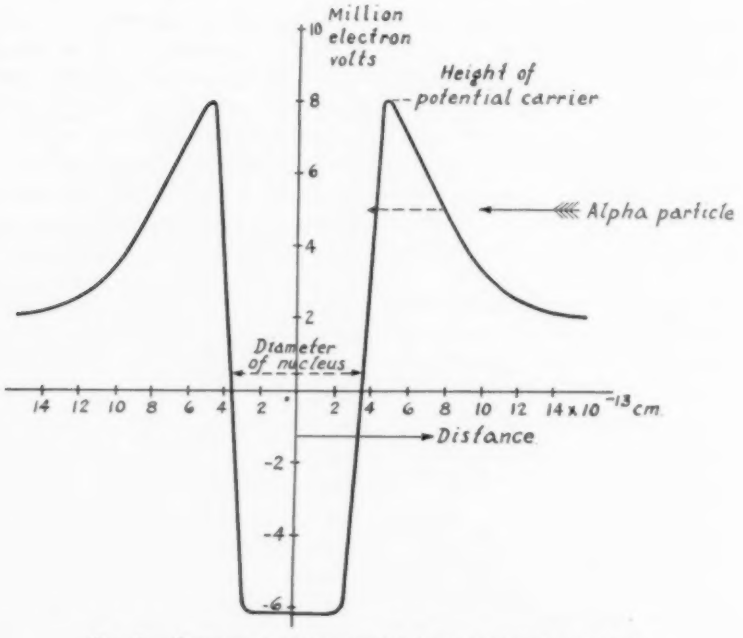


FIG. 1. POTENTIAL DISTRIBUTION OF ALUMINIUM NUCLEUS.

the material of the earth and also in the stars. Oxygen with 8 protons and 8 neutrons in its nucleus and silicon with 14 protons and 14 neutrons make up more than 75 per cent. of the weight of the lithosphere (surface of the earth). It seems that the pairing of protons and of neutrons plays a similar rôle in the nuclei as the pairing of electrons in the outer part of the atom, *viz.*, in its electron cloud. We see further in our diagram that up to number 20 (Ca) nearly all nuclei contain just as many neutrons as protons or perhaps one neutron more. For larger values of Z, the number of neutrons increases relatively to that of the protons, until the lead nucleus (Z = 82) contains about 50 per cent. more neutrons than protons. The more protons are present, the more are auxiliary neutrons necessary for stabilizing the nucleus, that is, for balancing the repulsion between the protons. Z = 83 is the nucleus with the highest atomic number which can be stabilized by a whole number of neutrons. All atoms of higher atomic number are unstable. Either they have a neutron too many and emit a negative electron spontaneously, or they contain a neutron too few and emit a positive particle. Up to Z = 83 the nuclei are stable when they lie in the "Heisenberg valley," as we call the narrow region filled by the stable nuclei in our diagram, limited by the possible ratio of the numbers of neutrons and protons. It is an "energy valley," as the property of stability is connected with relatively low values of energy. Increase of the number of neutrons in a nucleus produced by bombarding with neutrons "raises" it on the left "side wall" of our valley; it becomes unstable and falls down in the valley by emitting a negative electron (compare Fig. 3, where the observed unstable nuclei produced by neutron bombardment are plotted as crosses (x)). If nuclei with too few neutrons are produced, on the right-hand side of

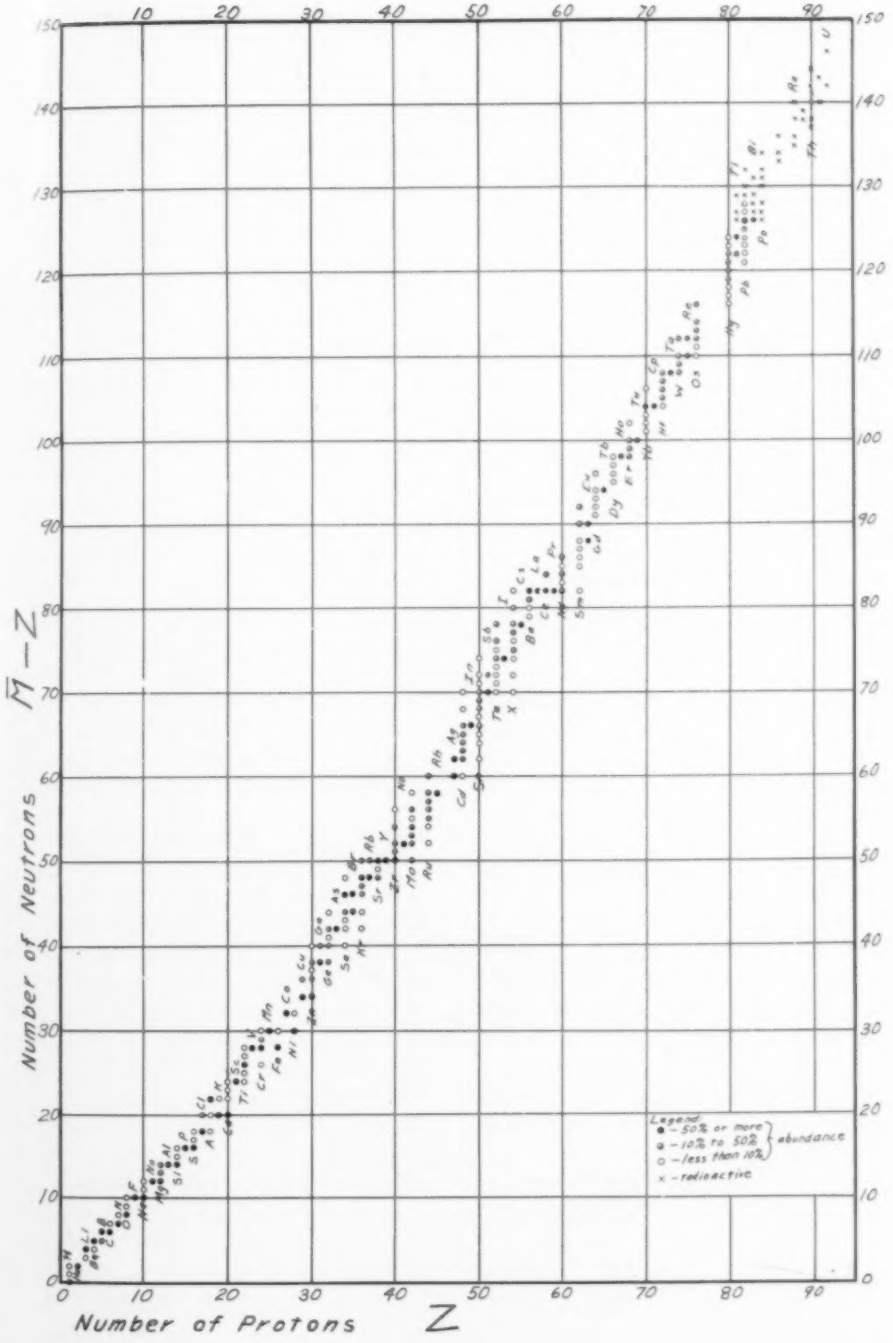

Number of Neutrons
M − Z
Number of Protons
Z
Legend
● – 50% or more
◍ – 10% to 50%
○ – less than 10%
abundance
× – radioactive

FIG. 2

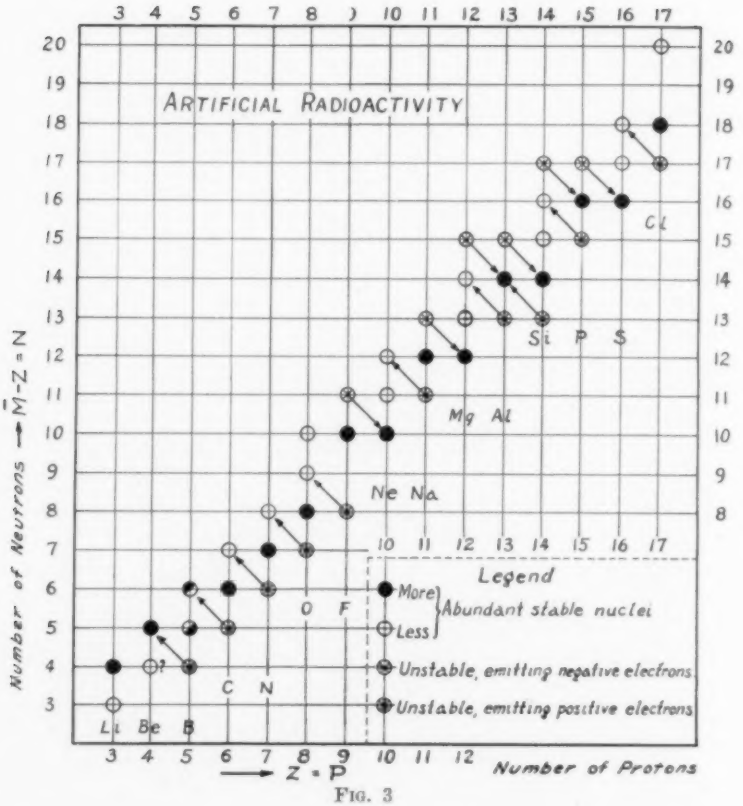

ARTIFICIAL RADIOACTIVITY
Number of Neutrons → M-Z = N
→ Z = P
Number of Protons
Legend
More
Less
Abundant stable nuclei
Unstable, emitting negative electrons
Unstable, emitting positive electrons
Li Be B C N O F Ne Na Mg Al Si P S Cl

FIG. 3

the valley (plotted in Fig. 3 as stars (*)), they also become unstable, but emit positive electrons.

Our diagram shows that emission of a negative electron is equivalent to the loss of a neutron and a gain of a proton, that is, a transformation of a neutron into a proton inside the unstable nucleus. Emission of a positive electron, on the other hand, is equivalent with the transformation of a proton into a neutron. In this way it is possible to describe the emission of electrons from nuclei, although they do not contain free electrons. Electrons may be produced or destroyed in the nuclei in a way similar to that in which light quanta are emitted and absorbed by atoms, only the total amount of charge remains constant. We have no detailed picture of the process occurring in the reciprocal transformation of neutrons and protons; they may be considered as two different quantum states of the same "particle." It is idle to ask which is a fundamental unit. This question has lost its sense.

GREGOR JOHANN MENDEL

A BIOGRAPHICAL SKETCH[1]

By D. J. HARBOU

SINDAL, DENMARK

On the sixth of January, 1884, the pioneer of genetical research, Gregor Mendel, died at Brünn, without having made his name generally known and without having received due acknowledgment of his scientific achievement. Yet so important was this work that Mendel will always rank among the great names of science.

To many people, Mendel and the history of his discovery are certainly not unknown, but the impression left by the general presentation is, in my opinion, not quite correct, and it is the object of this article to utilize the opportunity offered by the fiftieth anniversary of Mendel's death to direct the attention of the public a little more toward the man, Mendel, at the cost of the idea generally entertained of Mendel and his work.

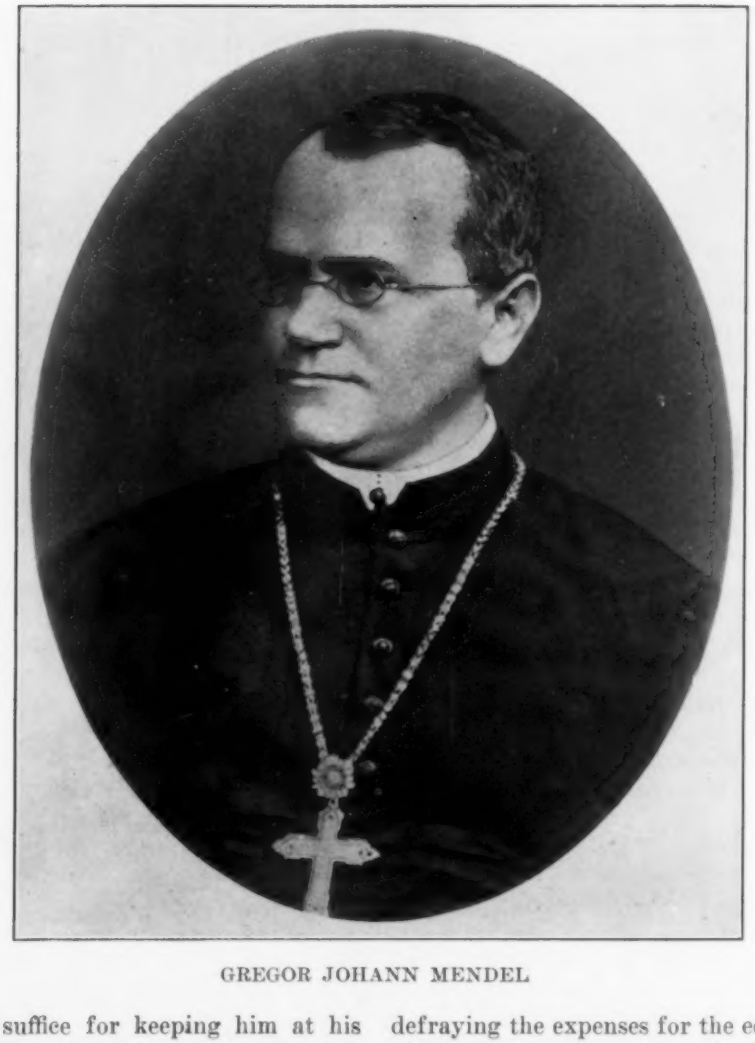
As a matter of fact, it is well worth the trouble to become a little better acquainted with the personality and life of Mendel, for it is very rare indeed to find instances of a man being in such perfect harmony with his career and his life work. On the other hand, a consideration of Mendel's character will afford an entirely satisfactory explanation of his discovery and his fate in life. The most prominent features of Mendel's character were an almost obstinate perseverance in what he considered to be right, united with clear judgment, respect for truth and justice, faithfulness to persons and institutions to whom he owed gratitude, and finally a practical sense of reality.

Through the parish records the name and family of Mendel can be traced back to the seventeenth century. The name was originally spelled Mandel, and his ancestors were peasants of German origin, many of them Protestants. Johann Mendel (Gregor was his adopted name as an Augustinian monk) was born on July 20, 1822, in Heinzendorf near Odrau, a village in Austrian Silesia, now Czechoslovakia. He was the son of Anton Mendel and his wife Rosina, whose maiden name was Schwirtlich.

Mendel's father was originally a socager, but through ability and diligence he became an independent proprietor of a farm. His chief interest was the orchard, and the various tasks to be performed there were learned by his son, Johann, at an early age. Mendel's interest in horticulture can undoubtedly be traced back to his early childhood. His scholastic talents he himself attributed to his mother's family, for he was accustomed to say in jest, but not without a certain pride, that he descended from a pedagogic family. This allusion was to his uncle, Anton Schwirtlich, who founded a private school in Heinzendorf for children too young to go to the parish school in the neighboring village.

It will be seen that Mendel was born of a respectable though poor family. In fact, his was an excellent home, where the relations between the various members of the family were of the best and where no effort was spared to give the children every possible opportunity in life. A digression is here made to further show the excellent spirit of this family and also because of the insight it gives into the character of Mendel. In later years when the small family income

[1] Adapted for publication by Dr. Edwin R. Helwig, University of Pennsylvania.



GREGOR JOHANN MENDEL

did not suffice for keeping him at his studies a younger sister voluntarily gave up her marriage-portion, thereby making it possible for him to continue his studies until assistance could be obtained elsewhere, *i.e.*, from the Catholic Church. Mendel was only nineteen years old at this time, and knowing his character it can be said with certainty that he did not accept this sacrifice without a sense of responsibility. That he accepted it at all shows the strength of his desire to proceed with his studies, and it can be taken for granted that he determined to repay his debt. He actually did so by defraying the expenses for the education of his three nephews, each of whom took a university degree.

He obtained his earliest instruction in the village school of Heinzendorf, established after the death of Schwirtlich. The schoolmaster, perceiving Mendel's abilities, encouraged him in his studies, and this was further stimulated by two older boys who attended the advanced school in Leipzig and spent their vacations during these years in Mendel's home. He was then permitted to enter the advanced school in Leipzig. Two years later he went to the Gymnasium

at Troppau, where one of his teachers, who was an Augustinian, pointed out to his pupil how well scientific studies could be pursued amidst the tranquillity of a monastery. By 1841, when Mendel had passed his final examination with credit at the Gymnasium, his plans for the future were already formulated. He would take a course of philosophy at Olmütz and then apply for admission into the Augustinian order, which was well known to be a sanctuary for scientific studies. At Olmütz Mendel proved to be an excellent student, though illness forced him to repeat his course so that it was not until 1843 that his studies there were concluded.

Mendel, equipped with the highest recommendations from his headmaster at Olmütz, applied for admission to "St. Thomas' Augustinian Foundation" in Brünn, the chief monastery of the order in this part of the country. The only handicap was that Mendel was not familiar with the Czech language, "which, however, he would undoubtedly quickly be able to learn." So, on October 9, 1843, Mendel entered the monastery as a novice.

The next three years were devoted exclusively to theological studies. On December 26, 1846, he took the solemn vow, adopting the name of Gregor. In 1847, he was ordained a priest and entered upon his duties as pastor of Alt-Brünn on July 26, 1848.

In 1849 Mendel went to Znaim as a deputy teacher of Greek and physics at the local gymnasium, but at the close of the summer term (1850) he returned to Brünn, where he taught natural history at the Brünn Technical School.

At length in 1851, when Mendel had entered his thirtieth year, his desire for scientific training in the natural sciences was realized. At the expense of the monastery he was sent to the University of Vienna, where he took a practical course in physical experiments and attended lectures on chemistry, zoology and botany. However, he endeavored primarily to acquire a knowledge of scientific working methods by frequent visits to museums and laboratories as well as through conversations with the scientists he met. Twice he attempted to take a scientific degree and both times failed.

This fact may cause some astonishment, and admirers of Mendel might be apt to seek the explanation in an unjust or too severe judgment of his work. However, his examination papers, provided with the commentaries of his cen-

MENDEL'S BIRTHPLACE

TWO VIEWS OF THE STRIP OF GROUND IN THE CONVENT GARDEN, WHERE MENDEL CARRIED ON HIS CLASSICAL EXPERIMENTS ON HYBRIDIZATION. THE OPEN WINDOW IS IN MENDEL'S ROOM.

sors, are still extant, and it appears that he had been judged fairly. He left the university without a degree but, as the future proved, with an excellent training and a knowledge of rational scientific methods.

A short time after his return to Brünn, Mendel was appointed teacher of natural history in the Brünn Modern School. He filled this post for fourteen years, and it was during these years that Mendel performed his famous plant experiments in the garden of the monastery.

At this time the scientific world of Europe was particularly interested in an explanation of the extraordinary multiplicity of living forms. Darwin tried to solve the problem by applying to nature the results obtained by breeders through the selection of breeding animals, thereby arriving at the idea of a "natural selection." Others were seeking the answer by investigating whether "intermediate forms" might not appear as hybrids between closely related species. However, it was noticed that the hybrids "went back to the parental form," and consequently no positive results were obtained from this method of attack.

Mendel himself tried to produce permanent variations in this way. He cultivated two varieties of Ficaria side by side for several years without observing any alterations or new forms. Consequently, to Dr. von Niessl, a member of the Brünn Society for the Study of Natural Science, he said, "As far as I can see nature can not make any material progress in this way with regard to the formation of new species. *There must be something more behind.*"

That Mendel had a clearer understanding of his problem than had any of his predecessors is shown in the foreword of his classical publication, "Versuche über Pflanzen-Hybriden":

> That it has not so far been possible to establish a universal law for the formation and development of hybrids no one, familiar with the extent of the problem and the difficulties with which experiments of this kind have to contend, can wonder. An entirely conclusive judgment of the question can not be given until detailed

THE WALL AROUND THE CONVENT GARDEN

experiments have been made on the most diversified families of plants. A careful consideration of the works hitherto undertaken will lead to the conclusion that so far none of the numerous experiments have been carried to such an extent or in such a way as to make possible a determination of the number of different forms in which the offspring of the hybrids appear or to arrange these forms with certainty within the different generations so as to ascertain their numerical relations.

At any rate a great deal of courage is required to undertake such an extensive work. It seems, however, to be the only possible way to reach the solution of a question which is undoubtedly of no small importance in its bearing upon the evolutionary history of organic forms.

The present work describes the result of such a detailed experiment. It is deliberately limited to a small group of plants and is now, after eight years, practically concluded. Whether the plan upon which the individual experiments have been arranged and conducted is in harmony with the problem to be solved must be submitted to the kind judgment of the public.

Mendel's insight into his problem is further shown by his choice of the garden pea for his experiments. In doing this he acted on a thoroughly considered plan, not on any casual, ingenious inspiration. Mendel states that he selected this plant because the various sorts possessed constant and easily distinguishable characteristics; the technique of artificial fertilization was comparatively simple and gave reliable results, and the fertility of the hybrids and their offspring was not diminished by hybridization or self-fertilization through a series of generations.

The characteristic feature of Mendel's experiments, as compared with earlier experiments of a similar nature by other investigators, was that Mendel crossed very closely related plants, from which he could obtain hybrids of undiminished fertility, and that he dealt statistically with each pair of contrasting characters for several generations.

The results which Mendel submitted to the Brünn Society for the Study of Natural Science on February 8, 1864, laid the foundation for all subsequent work on heredity. Without detracting from the importance of Mendel's work, it can be said with certainty that he did

PAVILION

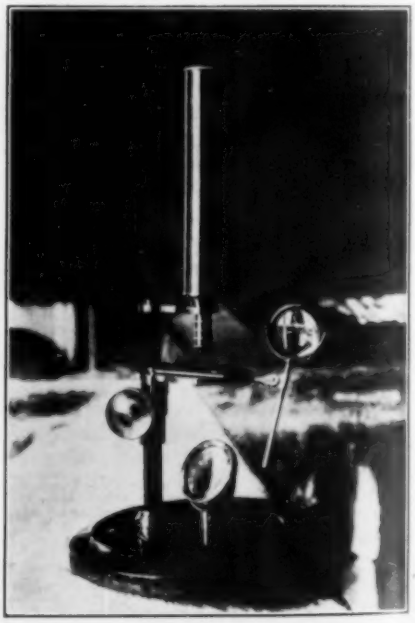
IN THE CONVENT GARDEN, WHERE MENDEL WORKED OUT THE RESULTS OF HIS EXPERIMENTS.

not aim at this goal. His object was to contribute to the solution of a problem of contemporary interest. With respect to this question—the origin of species—Mendel's results were, however, practically negligible. On his principles alone no general theory of evolution could be constructed, but as supplementary additions to Darwin's theory they might have profoundly influenced the development of the doctrine of evolution. Perhaps Darwin would have succeeded in effecting the synthesis between his own and Mendel's ideas that is happening only now, as a result of the last few decades of research. It is therefore much to be regretted that Darwin never became acquainted with the discoveries of Mendel.

On the other hand, the work of Darwin indirectly exerted a fatal influence on the reception given to Mendel's discovery. Due to Darwin's brilliant combination of facts and theories the problem of the origin of species was regarded as solved. This circumstance is undoubtedly the chief reason why Mendel's work remained unheeded, although the "Proceedings of the Brünn Society for the Study of Natural Science" were exchanged with 120 scientific societies and two of the most remarkable biologists of the time, Anton Kerner and Carl von Nägeli, are known to have been familiar with it.

It was Nägeli who directed Mendel's attention to the hawkweeds (Hieracium) upon which he next experimented. In view of Mendel's object to contribute to the understanding of the origin of species Hieracium was a particularly interesting genus, owing to its richness in varieties. However, it was an unfortunate choice due to a peculiarity of the genus Hieracium to form seeds in some cases without preceding fertilization. This fact was unknown in Mendel's time, but he quite correctly observed that identical methods of fertilization produced different results in the first generation.[2] Considering the rarity of this

[2] Some of the offspring developed from fertilized eggs and some parthenogenetically.



MENDEL'S MICROSCOPE

MENDEL'S BEEHIVES

method of propagation among flowering plants, it was a misfortune that was well fitted to raise doubts as to the reliability of the previously published experiments on peas. Nevertheless, Mendel published these results, but added that the work had hardly gone beyond a beginning. He suppressed his doubts as to the expediency of publishing such unfinished results because a number of years would be required to complete the projected experiments and the uncertainty of his being able to finish them induced him to submit the work at this time (June 9, 1869).

It was Mendel's plan to extend his experiments into the animal kingdom and he selected bees probably for the practical reason that he was already well acquainted with their care. Mendel had about fifty hives under observation in the convent garden. He collected queens of all available races, European, Egyptian and American, and cross-bred these races. It would be of the greatest interest to know the results obtained by Mendel, but it has been impossible to find them, although it is known that Mendel kept notes on this work. Probably Mendel destroyed them during the mental depression with which his last days were afflicted.

Due to the demands of other work, Mendel gave up his plant experiments in 1870, two years after his election as prelate. However, he continued his experiments on bees and his meteorological researches until a short time before his death. His meteorological work was no less intensive than his breeding experiments, and it alone would have been able to secure him the position of a scientist of high standing, if not of universal renown. Mendel's purpose in these meteorological observations was founded on an idea in which he again was before his time. He tried to prove a correlation between the appearance of solar spots and weather conditions. To this end the height of the barometer, temperature, percentage of moisture and ozone in the air and the water level in the town well were recorded three times each day for thirty years. These notes, written with an almost incredible care and diligence, leave a strong impression of Mendel's industry, perseverance and fidelity to a task once undertaken. During his last years, he probably entertained no hope of seeing the results of this work him-

self, but nevertheless he only reluctantly gave up this duty, which was the last tie that connected him with his lifelong passion for scientific research.

During the years in which Mendel carried out his various experiments he also performed his duties as a priest and teacher, and as the years accumulated, his reputation as one of the most prominent and able citizens of Brünn continuously increased. He was elected to several posts of honor, but the most curious expression of his fellow-citizens' confidence was, however, the election of the priest and scientist as chief director of the Moravian Mortgage Bank, a position for which his profound knowledge of human nature, his common sense and integrity and, not least, his ability to deal with figures made him eminently fitted. His versatility and interest in problems of all kinds is evidenced by the fact that he is still remembered in Brünn as an excellent chess player.

It certainly did not cause any wonder when in 1868 Mendel was chosen abbot of the monastery. His qualities and talents marked him as one eminently fitted for the daily management and administration of the large property of the monastery. Mendel owed his convent too much to take a light view of the duties of this responsible position. It was the monastery which had admitted the impecunious young student, had made him financially independent and had defrayed the expenses of his university training. It had also hospitably opened its garden for his experiments and Mendel undoubtedly felt grateful for this opportunity to repay his debt of gratitude by a faithful performance of his manifold duties. Besides, he hoped, as is shown by a letter to Nägeli, to have better opportunities for performing the hybridization experiments which would lead to a final victory for his ideas.

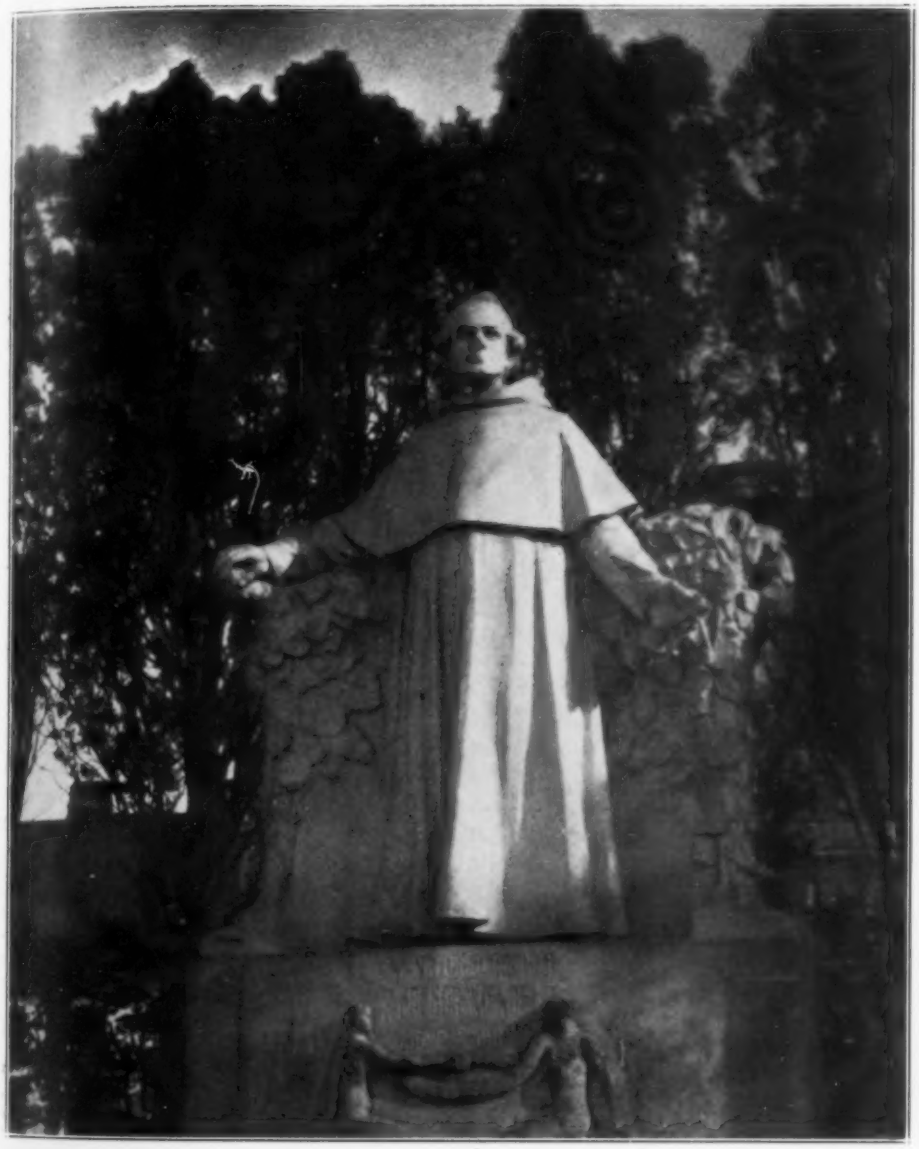
However, events decreed otherwise, for Mendel's time became occupied with his official duties. All Mendel's biographers agree in regretting this circumstance, a regret which is not, after all, quite reasonable. Had Mendel acted differently and, neglecting his official duties, continued his work in the experimental garden, science might have been enriched the more by an ingenious piece of work, but history would have lost one of its luminous examples.

A concurrent demand on Mendel's time was a conflict with the Austrian government, which deserves a more detailed mention, as it contributes greatly to our understanding of Mendel's character.

As my opinion of Mendel's conduct in this affair differs somewhat from that of earlier authors, I must consequently recapitulate the events on which my view is founded.

When the Pope in 1870 had proclaimed the doctrine of infallibility and declared himself the prisoner of Italy the German "Centrum" party requested the German Empire to reinstate the Pope in all his secular rights. Bismarck replied to the request of the "Centrum" by banishing the Jesuits from Germany, the "May Acts" of 1873 and the severance of diplomatic connection with the Vatican. A similar anti-Catholic movement simultaneously made itself felt in Austria which led to the Austrian "May Acts" of 1874, a body of laws in all respects certainly much more moderate than the German ones, but the tendency of which nevertheless was such that the Pope "ex cathedra" declared them null and void, now and in all eternity.

Among the "May Acts" was also the so-called "Religionsfondgesetz," according to which a fund for religious purposes was to be provided by imposing upon the rich benefices a comparatively heavy tax. The Augustinian monastery of Brünn had thus to pay an extra tax, amounting to about $8,000 a year. The



MENDEL'S MEMORIAL IN BRÜNN

Erected in 1910 through contributions from people of all nations. Executed by the Viennese sculptor Theodor Charlemont.

opponents of this law, among whom Mendel was one of the most active, maintained that the religious purposes aimed at were a question of general importance and not of special interest to religious institutions, which must be entitled, in this as in other respects, to equal treatment with all other taxpayers. This reasoning was logical, but the law was valid, having been passed by the "Reichstag" and sanctioned by the lawful government.

Mendel, however, on behalf of his monastery consistently refused to pay this tax. Eventually the property of the monastery was sequestrated and the income used partly for the payment of the tax, partly for the salaries of the administrators appointed by the government. Gradually the convents, which had made common cause with Mendel, were tired out by the rigorous measures of the government and only Mendel refused to give in, sending one protest after another for the government's consideration. Mendel's right and power to continue his policy were based on the fact that the infallible Pope had declared the May Acts invalid. As a man of common sense, Mendel could not fail to realize that the government had the means to collect the tax by force, so what did he expect to gain by his obstruction? In my opinion, his conduct can not be said to have been, as it is generally represented, a blind war against injustice carried on exclusively in the fanatic persuasion of having right on his side. Examples of Mendel's perseverance bordering on obstinacy have been seen but only where he was entitled to expect results. Mendel expected to obtain results by his perseverance, and subsequent events justified his expectations.[3] The first indication that Mendel was justified in expecting the government to "come to Canossa" was when in the middle of the conflict it offered Mendel the distinguished Leopold Order and a seat in the "Hirrenhaus" (senate). Mendel refused and continued the struggle.

The conflict, nevertheless, was telling on his health. His formerly cheerful and amiable disposition changed gradually into suspiciousness and misanthropy. Before the controversy was ended the chronic nephritis, from which he suffered during his last years, caused his death on January 6, 1884.

There is a trait of heroism in the best sense in the life of Gregor Johann Mendel, as shown by his early struggle against poverty to acquire knowledge and in the perseverance and enthusiasm with which he carried out his difficult experiments in spite of distractions and disappointments. Gregor Mendel died nameless as a scientist, his fame as such arising only after thirty-five years of oblivion. That Mendel himself was inwardly convinced of the importance of his work is seen from an utterance which he is said to have made frequently to his friends: "My time will come."[4]

[3] A few years after Mendel's death it proved that he had not fought in vain. Mendel's successor, through an adroit juridical treatment of the affair, managed to get refunded the money which the government had got "above what was due." Practically all that had been collected from the monastery was returned.

[4] Elsewhere he states that if the results of his pea experiments should prove to be universally valid "this would be of no small importance."

DETERMINING PARENTAGE

By Dr. ALEXANDER S. WIENER

DEPARTMENT OF PATHOLOGY, JEWISH HOSPITAL, BROOKLYN, N. Y.

THE difficulties of establishing paternity have been recognized from earliest times, as is indicated by the Roman law, "pater semper incertus." Similarly, according to the Talmud, no one is permitted to swear that he is a certain child's father; only the mother may swear, "This child is mine."

One of the oldest methods of determining parentage and one still employed in the law courts of some states, is by demonstrating the resemblance of the child to the putative father. Even photographs have been used as evidence. In most cases, only the general impression is depended upon, but at times, individual characteristics are emphasized, as in the following passage from Shakespeare's "Winter's Tale" (II, 3):

Paulina: It is yours;
And might we lay the old proverb to your charge,
So like you, 'tis the worse.—Behold, my lords,
Although the print be little, the whole matter
And copy of the father,—eye, nose, lip,
The trick of his frown, his forehead; nay the valley,
The pretty dimples of his chin and cheek, his smiles,
The very mould and frame of hand, nail, finger:—
And thou, good goddess Nature, which hast made it
So like to him that got it, if thou hast
The ordering of the mind too, 'mongst all colours
No yellow in't; lest she suspect, as he does,
Her children not her husband's!

This appeal, in which Paulina tries to convince Leontes that his wife, Hermione, has been faithful to him and that the child born to Hermione is his own, closely resembles some of the speeches made by lawyers to juries in law courts. In this connection, it is of interest to cite a bastardy case tried in the Court of Quarter Sessions of Fayette County, Pennsylvania, in 1931. In this case an Italian man was said to be the father of the illegitimate child of a white woman, but according to blood tests performed by Dr. Heise it was impossible for the accused man to be the father. Nevertheless, since the jury was convinced by the district attorney that the child in question showed some resemblance to the accused man's *father*, they returned a verdict of "Guilty."

It is well known that though close blood relatives frequently resemble one another, it is not uncommon for total strangers to exhibit similar characteristics. Furthermore, since the features are continually changing, especially in the transition from childhood to maturity, to judge resemblance of infants is highly unreliable. For this reason, in certain states, *e.g.*, New York State, the law does not permit the exhibition of the child to the jury for purposes of proving paternity. And in Shakespeare's play, cited above, Leontes was not convinced by Paulina's arguments that Hermione's child was his. However, as late as 1931, a jury in Pennsylvania allowed itself to be convinced by such arguments and entirely overlooked scientific proof by blood tests of the accused man's innocence. Fortunately, the judge did not allow himself to be deceived, and finding the verdict to be against the evidence, he declared a mistrial. The woman never applied for a new trial, since shortly afterwards the infant's features began to change, and now,

three years after the trial, the child has features definitely Negro in character.

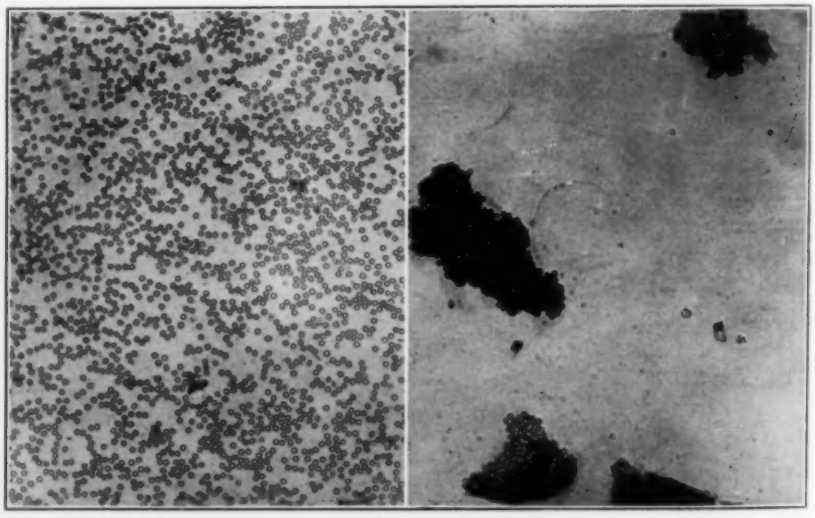
At any rate it is fortunate that the courts do not pursue this belief to such an extreme as, according to Strabo, was done in Carthage, where the children, when they reached the age of two months, had to be examined by a special committee, and if their resemblance to the father was not great enough, they were killed.

That attempts were made to devise other methods of determining paternity is not surprising. The ancients attributed certain mystic powers to the blood, and such beliefs have survived to the present day in sayings such as "blood will tell" and "blood is the base of all." As interesting examples of such superstitions, the following methods of detecting blood relationship are cited from Chinese and Japanese books of the thirteenth century:

A drop of blood is obtained from each of the two supposedly related individuals by pricking their fingers; and the two drops of blood are allowed to fall into some water. If the two persons are blood relatives, the bloods will flow together. Or, in the event that the mother or father is dead, the blood of the supposed son or daughter is allowed to fall on one of the bones of the dead parent's skeleton. Only if the blood penetrates the bone, so that it cannot be washed off, is the existence of a true blood relationship established.

In Bosnia, recently married young men use a sort of "God's judgment" when the child is born before the end of the ninth month. The husband places the child on the threshold; if it falls into the house, then it is surely his, but if the child falls out of the house, the husband disowns it.

The judgment of Solomon is often cited as an illustration of God-sent wisdom. His conclusion was but natural, and nowadays King Solomon would merely be called a clever psychologist. Interestingly enough, the newspapers recently contained the report of a modern counterpart of this case. Each of two women claimed that a certain child



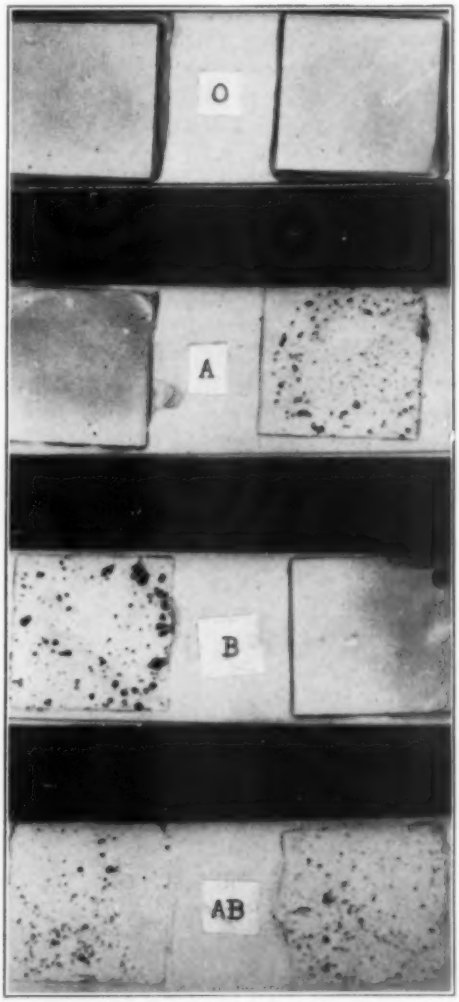
MICROSCOPIC APPEARANCE OF THE AGGLUTINATION TESTS

Left: NEGATIVE REACTION—EACH RED BLOOD CELL IS SEPARATE AND DISTINCT. *Right:* POSITIVE REACTION—THE RED BLOOD CELLS ARE AGGLUTINATED TOGETHER IN LARGE CLUMPS. (MAGNIFICATION 1: 80.)

was her own, and the judge stated that since he had no way of determining to whom the child belonged, he would settle the case by sending it to an institution. One of the claimants expressed satisfaction with this decision, since she would prefer to have the child sent away than given to the other woman; the second claimant stated, however, that she would rather give up the child to the first woman than have it sent to an institution, where it would be deprived of a mother's love and care. The child was then awarded to the second woman.

A more scientific method of establishing parentage is based on the fact that when certain rare abnormalities are present in one or both of the parents, they frequently reappear in some or all of the children. The remarkable accuracy of the heredity of some of the digital malformations is illustrated by a paternity case reported by Mohr (1921). The father had a pronounced shortening of the fingers and toes 2, 3 and 4, caused by incomplete development of the second row of phalanges. The thumbs were normal, but the basal phalanx of the great toe was shortened. Since the hands and feet of the child showed the identical malformation, the man was adjudged the father.

Inasmuch as certain abnormalities are inherited as "recessives" they may appear in children both of whose parents are apparently normal. Until comparatively recent times, the appearance of such monstrosities was attributed to certain experiences of the mother during her pregnancy. The belief that if the pregnant woman should see an ugly or terrifying object, it will be reproduced in the child dates from the remotest antiquity. Novelists (Goethe, Shakespeare, Dickens, etc.) have used this idea as a favorite theme, and many names great in the history of medicine could even be quoted in its support. In a novel by Arthur Schnitzler, a certain woman from a small town gives birth to a Negro child following a visit to a



BLOOD GROUPING ON GLASS SLIDES

ACTUAL SIZE. THE TESTS WERE PERFORMED BY MIXING ONE DROP OF THE UNKNOWN CELL SUSPENSION WITH ONE DROP OF GROUP A SERUM (LEFT), AND ONE DROP OF CELL SUSPENSION WITH ONE DROP OF GROUP B SERUM (RIGHT). A POSITIVE REACTION IS RECOGNIZED BY THE APPEARANCE OF BRICK-RED GRANULES, DUE TO THE CLUMPING TOGETHER OF THE BLOOD CELLS, WHEREAS IN A NEGATIVE REACTION THE BLOOD SUSPENSION IS UNAFFECTED AND APPPEARS HOMOGENOUS TO THE NAKED EYE. GROUP O BLOOD DOES NOT REACT WITH EITHER SERUM, GROUP A BLOOD REACTS ONLY WITH GROUP B SERUM, GROUP B BLOOD ONLY WITH GROUP A SERUM, AND GROUP AB BLOOD REACTS WITH BOTH SERA.

Negro troupe in Vienna. The husband, who has complete faith in his wife's fidelity, is convinced that this is a case of "maternal impressions" and collects numerous examples of this phenomenon out of the literature. In Shakespeare's play "Titus Andronicus," however, when Tamora gives birth to a colored infant, she tries to do away with it, since she knows that her husband will not be deceived so easily by "pseudoscientific arguments." Thomsen has recently reported a case tried in Denmark, in which the illegitimate child of a servant girl possessed an unusual deformity of the fingers that corresponded exactly to that of the mother's employer. The claim for maintenance for the child was refused by the court, however, since it was held that the continual observance by the mother of her master's deformity fully accounted for the appearance of the anomaly in her child. This illustrates how difficult it is to destroy popular belief in certain superstitions, even in the absence of any rational basis.

Blood Tests and Paternity

The problem of determining parentage has not been entirely solved yet, but recently methods have been discovered, based on well-established scientific facts, which make it possible to render definite decisions in a certain percentage of cases. These methods are an outgrowth from a relatively new branch of medicine, namely, serology.

The blood is made up of two main fractions, the red cells, which give the blood its color, and a fluid called the plasma (or serum[1]). In the human red blood cells there are two substances called agglutinogens A and B. If an individual possesses both these substances in his blood cells, he is said to belong to group AB, if neither, he belongs to group O; if he possesses only A, to group A; and if only B, he belongs to group B. In the serum are two substances, called agglutinins, α (or anti-A) and β (or anti-B). If a serum containing agglutinin α is mixed with red blood cells containing the agglutinogen A (group A or group AB), these cells will be clumped together (or agglutinated) or may be entirely destroyed. On the other hand, such a serum would not affect red blood cells not containing A (of group O or group B). Similarly, agglutinin β acts on bloods of group B and group AB, but not on bloods of group O or group A. Naturally, an individual of group A can not have agglutinin α in his serum; and neither can a group B individual possess agglutinin β. The constitution of the four blood groups and their approximate frequencies in New York City are as follows:

Group	Frequency (Per cent.)	Red Blood Cells (Agglutinogen)	Serum (Agglutinin)
O	40	—	α and β
A	40	A	β
B	15	B	α
AB	5	A and B	—

The technique of the tests is very simple. All that is required is a suspension of the red blood cells of the individual to be tested, which is prepared by mixing a few drops of blood from the finger with isotonic salt solution. Two sorts of testing sera are used, one containing agglutinin β alone (group A), the other agglutinin α alone (group B). These sera are obtained from normal individuals by collecting blood which is allowed to clot. After the clot contracts, the clear yellow serum can be separated. The actual tests are performed by mixing a drop of cell suspension with one drop of each of the two testing sera. If the cells are agglutinated by both sera, the individual being tested belongs to group AB; if by neither, to group O; if

[1] The fluid remaining after coagulation of the plasma is the serum.

only by group B serum, to group A; and if only by group A serum, to group B. The difference between a positive and a negative reaction is shown in the two illustrations.

The human blood groups, described above, were discovered in 1900 by Dr. Karl Landsteiner, of the Rockefeller Institute, who was also the first to suggest the application of the discovery to blood transfusion. It may be of interest to point out, in passing, the significance of this aspect of blood grouping. In the very first blood transfusions performed on man the blood of animals, especially the lamb, was used (Denys, 1667). This procedure was frequently followed by fatal reactions, which were finally explained by the discovery that animal sera agglutinate or destroy human red blood cells, and human serum agglutinates the blood cells of lower animals (Landois, 1875). Attempts were then made to perform transfusions using human blood, but even then fatal reactions continued to occur. This was puzzling, since it was assumed that the bloods of individuals of the same species must be identical, but the mystery was solved when Landsteiner discovered the existence of the human blood groups. At present, blood transfusions can be safely performed by selecting a donor belonging to the same group as the recipient, and, in New York City alone, 10,000 transfusions are performed every year, so that the discovery of the blood groups is responsible for the saving of thousands of lives.

To return to the subject of this paper, the medicolegal application of blood grouping for the exclusion of paternity depends upon the following three important properties of the blood groups: (1) The blood group of any individual can be determined at birth or shortly thereafter; (2) the blood group of every individual remains constant throughout life and does not change regardless of age, disease, medication, etc.; (3) the blood groups are inherited in accordance with Mendel's laws.

That the blood groups are inherited has been known since 1910, when, after a preliminary study by Ottenberg and Epstein, von Dungern and Hirszfeld found in an investigation on 72 families with 102 children that the agglutinogens A and B never appear in the blood of a child unless present in the blood of one or both parents. This rule has been corroborated by many other independent investigators on tens of thousands of families. The results of these studies make it possible to predict what the groups of the children must be if the groups of the parents are known, as is shown in matings 1 to 6 in Table 1.

TABLE 1

THE LANDSTEINER BLOOD GROUPS IN PARENTS AND CHILDREN (BERNSTEIN THEORY)

Groups of parents	Groups of children possible	Groups of children not possible
1. O × O	O	A, B, AB
2. O × A	O, A	B, AB
3. O × B	O, B	A, AB
4. A × A	O, A	B, AB
5. A × B	O, A, B, AB	———
6. B × B	O, B	A, AB
7. O × AB	A, B	O, AB
8. A × AB	A, B, AB	O
9. B × AB	A, B, AB	O
10. AB × AB	A, B, AB	O

In interpreting their results, von Dungern and Hirszfeld postulated that the agglutinogens A and B were inherited independently of one another. By making certain statistical calculations, however, Bernstein (1925) was able to prove that this assumption was incorrect and that actually the heredity of the blood groups depends upon three allelomorphic genes, A, B and R. This newer development does not affect the law discovered by von Dungern and Hirszfeld, since according to Bernstein's theory

also it is impossible for the agglutinogens A and B to appear in the child's blood unless present in the blood of one or both parents. In addition, however, according to the theory of three allelomorphic genes, a group AB parent can not give rise to a group O child, and a group O parent can not have a group AB child. These additional exclusions are listed in matings 7 to 10 of the table.

How this knowledge can be applied is best illustrated by citing an actual case. In a recent case tried in the Court of Common Pleas of New Haven County, a woman falsely accused a man of the paternity of her illegitimate child. Although the defendant repeatedly denied his guilt, the weight of public opinion was against him. The bloods were sent to the present author for examination, and it was found that the man belonged to group A, the woman to group O and the child to group B. Since the child possessed the agglutinogen B not present in its mother's blood, the true father could only belong either to group B or group AB. Confronted with this evidence, the woman withdrew her charge and the man was acquitted. In this case, therefore, the blood tests prevented a miscarriage of justice.

Suppose, however, that it had been found that the accused man belonged to group B or group AB. This would not prove that he was the true father any more than another man belonging to either of these groups. In such an event, the blood tests would be of no avail. In general, therefore, blood grouping can be used only to *exclude*, not to *prove* paternity. If it is known, however, as is sometimes the case, that one of two men is the father of a child, if one of the men can be excluded by the blood tests, it follows that the other must be the father of the child.

In 1930 there was an interesting case in Chicago, which illustrates another application of the Landsteiner blood tests. In this case, the problem of identifying two newborn infants which had been interchanged in the hospital was solved by blood grouping. One week after taking their baby home, Mr. and Mrs. B. discovered that the baby had a label on its back with the name "W.". At the W. home the baby was found to bear the label "B." All six individuals were then grouped, with the following results:

Mr. B. ..... group AB	Mr. W. ..... group O
Mrs. B. ..... group O	Mrs. W. ..... group O
Baby bearing label "W." group O	Baby bearing label "B." ..... group A

Since a group A child can not occur in the W. family, but may occur in the B. family (see Table 1); and since a group O child can not occur in the B. family but is possible for the W. family, it was evident that the babies were properly labeled but had been taken to the wrong house.

As is seen from Table 1, only with certain combinations of the blood groups of the mother and child is a decision possible. Thus, in one sixth of the cases where false accusations are made, blood grouping can establish a man's innocence. Until recently nothing could be done about the remainder of the cases. In 1927, however, Landsteiner and Levine discovered two additional agglutinogens, M and N, in human red blood cells. These agglutinogens had not been previously observed because normal human or animal sera do not contain agglutinins against M and N. However, by injecting human blood into rabbits or other animals, such as cats and goats, sera may be obtained with agglutinins for M and N. The agglutinogens M and N are entirely independent of the agglutinogens A and B and define three distinct types of human blood as follows: Type M (blood possessing only agglutinogen M)—this type makes up approximately 30 per cent. of the general population; Type N (blood possessing only agglutinogen N)—20 per cent.;

Type MN (blood possessing both agglutinogens, M and N)—50 per cent. No individuals have been found whose blood lacks both agglutinogens M and N in more than 30,000 tests made to date.

In 1928, Landsteiner and Levine showed that the MN-types are also inherited according to Mendel's law. The theory of heredity they proposed has been confirmed by studies by many independent investigators on several thousand families so that the medicolegal application of the MN type is entirely reliable at present. The mechanism of heredity of the agglutinogens M and N is given in Table 2. This table is summarized in the following two laws: (1) The agglutinogens M and N can not appear in the blood of a child unless present in the blood of one or both parents; (2) a type M parent can not give rise to a type N child, and a type N parent can not have a type M child.

TABLE 2

THE AGGLUTINOGENS M AND N IN PARENTS AND CHILDREN

Types of parents	Types of children possible	Types of children not possible
1. MN × MN	M, N, and MN	
2. MN × N	N and MN	M
3. MN × M	M and MN	N
4. M × N	MN	M and N
5. N × N	N	M and MN
6. M × M	M	N and MN

A few cases will be cited which illustrate the practical application of the MN-types in cases of disputed paternity:

In one case the question arose whether the husband or another man was the father of a child. The husband was willing to support the child, regardless of its paternity, but the wife insisted she would live only with the child's true father. Since both men belonged to group A, no decision could be made on the basis of the classic blood groups. When the bloods were tested for the properties M and N, however, the lover could be definitely excluded, since he belonged to type M, whereas the child belonged to type N. Of the two men, therefore, only the husband could be the father of the child. The complete results of the blood examinations were:

BLOOD OF	GROUP	TYPE
Husband	A	M
Lover	A	N
Wife	B	M
Child	A	M

As frequently occurs when attempts are made to make useful application of scientific knowledge, the blood tests in this case failed to produce the anticipated beneficial result, since the woman finally elected to go off with the lover.

In the second case, the problem of determining the paternity of three children arose. Without going into the details of the story, the results of blood tests may be summarized as follows:

BLOOD OF	GROUP	TYPE
Husband	O	MN
Lover	A	N
Wife	O	MN
First Child	O	MN
Second Child	O	M
Third Child	A	N

Since two parents belonging to group O can only have group O children, the third child, belonging to group A, could not be the husband's, but it could be the lover's. With regard to the other two children, no definite statement can be made on the basis of the blood groups, since either man could have group O children with a woman of group O (see Table 1). The tests for M and N yielded further information, since the second child, belonging to type M, could not have a type N parent. This child, therefore, could not be the lover's but could

be the husband's. No definite statement can be made about the first child, since either man could have type MN children with a woman of type MN (Table 2). In this case, therefore, the paternity of two out of three children was determined by the combined use of all four agglutinogens A, B, M and N.

It has been calculated that if both methods are used, a falsely accused man has one chance in three of exonerating himself by the blood tests. Fully 7 out of 10 cases of interchange of infants, such as the Chicago case described above, can be solved by the tests.

Paternity and the Law

The Landsteiner blood tests have been applied in cases of disputed paternity since 1924 in Europe. Some of the countries in which the tests are being applied are Austria, Germany, Denmark, Italy, Sweden, etc. As early as 1929, Schiff was able to compile statistics on over 5,000 European cases in which the tests had been used, and this figure has probably increased considerably by the present time. In this country, on the other hand, aside from isolated instances in Connecticut, Ohio, Illinois and Pennsylvania, the method has not been applied. Although a highly conservative attitude is indeed desirable when applying new scientific discoveries in legal procedures, still the blood tests for excluding paternity have passed well beyond the experimental stage, so that our courts would do well to follow the precedent set in European countries.

It is of interest to discern the attitude of our courts when confronted with the problem of legitimacy. According to existing laws in this country, any child born in lawful wedlock is considered to be legitimate. From the earliest days of the law, this presumption, which is given in the old Roman law "pater est quem nuptiae demonstrant," has been extremely difficult to overcome. At one time the law's attempt to protect the child's good name went to absurd degrees, as may be gathered from the rule of the "Four Seas" in England. On the basis of this law, one court decreed that a child born in England was legitimate, even though the husband resided in Ireland during the whole term of his wife's pregnancy and for a long time previously, because Ireland was within the King's domain. This absurd rule was modified in 1807, and to-day the presumption of legitimacy, though difficult to overcome, may be cleared by adequate proof in this country.

A brief review of some of the methods used in our courts to prove or disprove parentage will serve to emphasize the value of the blood-grouping tests:

Duration of Pregnancy. By duration of pregnancy is meant the interval in days between the time of impregnation and the beginning of labor. The average duration of pregnancy is stated to be approximately ten lunar months or 280 days, but there have been live "premature" births as early as 215 days and "postmature" births as late as 330 days. In some countries, the legally acceptable limits of the duration of pregnancy are fixed by law. In France, for example, legitimacy of a child born 300 days after the dissolution of a marriage may be contested. In American and English courts a more conservative attitude is adopted, since every case is judged on its own merits.

The main shortcoming of this criterion of legitimacy is that it can be practically applied in only rare instances, in contrast to the blood-grouping method which may be used in every case. Furthermore, in most cases where one attempts to use this evidence, there is a conflict in the testimony of the mother and putative father as to the date of intercourse. Thus, in a case recently tried in a New York court, a man sought

an annulment of his marriage, since his wife gave birth to a child only five months after their wedding. He denied having had intercourse with his wife before marriage, but she contended that there had been such relations. In order to protect the interests of the child, the testimony of the wife was accepted and the application for annulment denied. Possibly this case would have been solved by blood tests.

Impotence and Sterility. Sterility refers to the inability to procreate, whereas impotence refers to the physical inability to perform the sex act. While there is frequently impotence without sterility, the incapacity usually involves both functions simultaneously.

This entire subject is fraught with exceptions and doubts, since it is difficult to establish with certainty the complete absence of live spermatozoa. The mere fact that intercourse is difficult or unsatisfactory does not necessarily establish sterility.

The fallacy of attempting to establish paternity by resemblance has already been pointed out. Of no greater merit is evidence based upon the presence of the same venereal disease in mother, man and child, since there is a strong possibility of coincidence.

From the foregoing discussion, it is evident that the introduction of the blood-grouping tests would be a valuable aid to our courts in cases of disputed paternity. In a recent case in the Supreme Court of New York, a man was accused of the paternity of an illegitimate child, and the mother of the child sued him for civil damages. In a splendid opinion, Justice Steinbrink ordered blood tests, since the man in question denied paternity or ever having had relations with the woman. The woman refused to submit to the tests, however, and appealed from Justice Steinbrink's order. The Appellate Division reversed the decision on the grounds that there was no statutory authority for such an order, and that the tests were not in the child's interest and were a violation of its rights. If the Appellate Division implied by this that anything the mother does for the child, even if it involves making false accusation, is to be looked upon with approval, it is setting a very dangerous precedent.

Under the existing laws, if testimony concerning the blood groups of the individuals in a case of disputed paternity is available, it is admissible as evidence. The main difficulty is in getting the individuals involved to consent to the tests. In Germany many courts have adopted the policy that refusal of the woman to submit to the tests is presumptive evidence of the falsity of her accusation. In this country, however, such a procedure is not permissible. It would be helpful if laws will be passed empowering the courts to order individuals to submit to blood tests where they are material, in those jurisdictions where blood tests are not compulsory at present.

WINTER INJURIES AMONG TREES AND SHRUBS

By JOHN G. JACK

ASSISTANT PROFESSOR OF DENDROLOGY, THE ARNOLD ARBORETUM, HARVARD UNIVERSITY

INJURIES to trees and shrubs and other vegetation in the winter of 1934 were so pronounced that it seems worth while to give some of the particular facts concerning the damages caused by temperatures and other climatic conditions which were so unusual that they affected many plants which we had heretofore regarded as hardy in our plantations. The records of the Weather Bureau do not show more severe and long-continued cold for the region which surrounds Boston, the record being applicable to a large proportion of the northeastern United States. Records of more than 30 degrees below zero, of Fahrenheit, were noted in some sections in eastern Massachusetts, and low temperatures of 15 to 30 degrees below occurred about Boston at the end of December, and registerings of from zero to 20 degrees below were almost continuous during the first two weeks of February. The cold was sometimes accompanied by severe winds. The intensity of cold varied much in different localities within a mile or two. Long, thin cracks developed in the trunks of old trees which had endured our winters for a century or more.

The Arnold Arboretum is commonly looked upon as more or less of a testing station of the hardiness or endurance of many of the woody plants which have been introduced from other parts within the temperate zones of the globe. Yet no safe estimate can be made of the probable behavior of any plant when judged by latitude alone. Many other factors must be considered. In addition to latitude and altitude and other ecological conditions, plants may prove satisfactory or useless for particular purposes, according to whether they were originally collected on the northern or southern or eastern or western side of a mountain or mountain range. In such cases temperature and rainfall or snowfall may be the dominant features affecting the endurance of plants when removed from their natural homes and brought into cultivation and under new environment. The amount and season of rainfall, proximity to the sea and the ocean currents, clouds, fogs, prevailing winds, soil, drainage, fertility of the ground and other conditions are factors likely to have a bearing upon the results of our labors.

In cultivation the careful and painstaking grower of exotic plants, which it is hoped may be naturalized or acclimated, wisely tries to imitate so far as practicable the best native or natural conditions, if known, of the introduced plants with which he has to deal. Upon the proper placing, the soil, drainage and moderate protection, success or failure may follow. Occasionally we have exceptional or catastrophic conditions, such as the very unusual and prolonged low temperatures during the past winter of 1934, when most ordinary precautions fail to prevent serious damage to plants ordinarily hardy.

The reason why, under unusually severe conditions, plants of a certain species may survive in good order in one part of a yard or garden, while failing in another, may not be possible to determine with any certainty. Intensity of sunlight with rapid alternate freezings and thawings, winds or draughts of cold air on different sides of a house, or in different parts of a yard may cause a marked difference in behavior in plants

of the same origin. Trouble may be due to weakness of an individual. A few shovelsful of soil differing in composition from that given adjacent plants may have some effect. Injury may follow poor drainage. The application of too much manure or fertilizer too late in the season and late cultivation of the soil, thereby inducing late growth and the production of vigorous stems or shoots which do not ripen fully before autumn cold ends growth for the season, are factors which deserve attention. Such poorly ripened wood may pass through a mild winter without apparent injury, but if subjected to such unusually severe tests as in the past year it is very likely to be destroyed. Plants which fruited heavily the previous season may be weakened and so be rendered especially susceptible to unusually adverse conditions.

In cultivation trees or shrubs of a known or suspected tender nature should generally be well protected, if young, for two or three years after planting out, so that the root system may become well extended and adjusted to the surroundings. They should be planted on well-drained soil, preferably on rising ground or on the tops of slight ridges or knolls rather than in depressions or low areas surrounded by raised ground. While plants which have proved hardy may not be affected on low situations, the more tender sorts should do better on slopes well above depressions or areas surrounded by walls or thick growths of trees and shrubs. The coldest air settles in such "pockets" and may not have any easy "air flow" outlet. Those areas which have a good air current or flow from a superior elevation may have frost immunity for perhaps two or three weeks longer in spring and autumn than ground which is lowlying and where the air is comparatively still. This is important when considering the blooming season in flower gardens.

In connection with the question of hardiness there is often much confusion in the mind of planters and plant purchasers concerning the source of their trees and shrubs. Outside of a particular region, where a species may be native, the idea is prevalent that an ordinarily hardy plant may prove less so if purchased from a southern nursery, even if that nursery originally procured its stock from a northern nursery or a northern region where the species was indigenous. From our present knowledge that idea is erroneous. Millions of trees and shrubs, budded or grafted, or cuttings, are annually grown in our southern states, where labor is cheap and growing season long, and shipped to northern nurseries to be resold to the public. The propagation of different kinds of the common peach may be cited as an example. A native of temperate parts of China, the various forms appear to retain their hardiness whether grown in a warm temperate zone, as our southern states, or in the cooler northern parts of our country, excepting extreme portions where temperatures commonly fall to 15 or 20 or more degrees below zero of Fahrenheit. On the other hand, certain species of trees and shrubs, which are native only to our southern states, or similar regions abroad, are not rendered more hardy by growing or propagation in a northern nursery. There is something constitutional in the species which apparently resists all such temporary changes, although improvements may be developed by selection through generations raised from seed. However, the stocks used in propagation, besides the grafts or buds or other parts of the plant to be divided or increased, may prove a decided factor in regard to the question of hardiness. For example, if a crabapple which was known to be perfectly hardy in the North should be propagated in the South by grafting, and the grafting stocks chosen there were of a more tender character than the scions, the plants might not prove hardy when re-

turned to the North because the roots of the stocks might be winter killed and this would be fatal for the grafts. This experience has been carefully noted and guarded against by experimenters and orchardists in our rigorous northwest. Of course propagation by cuttings from an individual, where no foreign element like stock intervenes, is not affected. This is also true of seeds, but among seedlings some individuals may prove to be more robust than others and these may be selected and propagated by the hand of man. In grafting or budding it was formerly considered that the stock had little influence upon the scion, but recent experiments have shown that the grafts or scions may really be more affected than was formerly supposed.

The winter injury to our trees and shrubs may manifest itself in various ways. In extreme cases the whole plant, including the roots, dies and fails to put forth leaves in the spring. Very often it is killed to or near the ground, leaving a living base to develop new shoots if the plant is a shrub, as shown in many forsythias, or basal branches or sprouts may sometimes be trained to form new tree stems, as we expect from the Davidia. Again the damage may so affect portions of the bark of main limbs or trunks of trees that the bark may be separated from the wood or the inner bark becomes brown and dry, thus checking the normal flow of sap. In such cases leaves and flowers and a stunted growth may develop on parts of the tree in spring, but soon after these demonstrations of activity further growth is checked, the leaves and flowers wilt and the plant, or a large portion of it, is soon practically dead.

The famous Davidia or Dove Tree, of China, in the Arboretum seemed to show life in some branches as spring advanced, but it was only a feeble attempt at recovery and within a few weeks the trees were dead to the ground. The trees were 15 to 20 feet high. Although flower buds had been hurt or killed in some previous winters they had not shown other injury.

During the past winter many cherry, apple and other trees showed the bark killed on the sunny southwestern side of the trunks or the upper, sun-exposed sides of large limbs, the shaded side remaining sound. Fruiting bodies of fungi have developed during the summer, indicating rapid decay. The damages on such areas were probably caused by rapid freezings and thawings, perhaps supplemented by coatings of ice. Many shrubs showed a mixture of dead and living branches requiring careful pruning. It is common knowledge that in many of our cold seasons the dormant flower buds of some trees and shrubs, like peaches, almonds, sweet cherries, some hazels, and numerous others, may be killed by the cold and be flowerless in spring while the hardier leaf buds survive and produce a profusion of foliage.

In all cases of winter killing the snow line during the severest part of the season is important. A great many of the smaller shrubs may not be damaged because of protection afforded by snow, and the branches very near the ground on larger shrubs or trees may remain green and fresh and produce foliage or flowers when the rest of the plant may appear in a dead or dying condition.

In recent numbers of the *Bulletin of Popular Information,* issued by the Arboretum, lists have been given of a large number of species of deciduous shrubs and trees which were killed or injured by the unusually severe winter of 1934.

The yew and the conifer families suffered much from the cold, although on the whole the damage was less than the injury to many of our broad-leaved, deciduous trees and shrubs. Of some species the flower buds, or most of them, were destroyed. In some instances the buds which should ordinarily develop into new shoots or twigs were so greatly injured that they have failed to make

normal growth, so that affected trees will probably lose many of their branches and much of their symmetry, or they may die. While the Japanese Yew, *Taxus cuspidata*, generally passed safely through the winter there were plants of this species which showed some injury. This often took the form of arrested development of the terminal buds and shoots. These sometimes showed a browning of leaves. Generally the dormant buds started and a checked and irregular growth developed as the season advanced. The European or English Yew, *Taxus baccata*, suffered severely in some instances. Occasionally branches were killed or tips of branches failed to show life and some pruning became necessary. A careful inspection of such injured branches in midsummer showed very small latent buds developing in the axils of leaves or leaf scars. These in another year should develop into good normal shoots or branches. It should be noted that some of the plants which have been named as hybrids between the Japanese and European yews have shown less hardiness than the Japanese parent, though hardier than *Taxus baccata*. Some plants of the hybrid *T. media* show some injury on tips of branches, while *T. media hatfieldii* was much more seriously hurt.

After growing in the Arboretum for many years, during which it flowered and fruited, the Japanese *Torreya nucifera* was nearly killed but, although the terminal parts of the branches failed to recover, new shoots developed on the basal portions so that there is a prospect of the trees regaining a green aspect and good form after several years.

Among the conifers the pines as a group suffered less than some other genera. Some browning of the foliage occurred, but twigs and buds usually developed a full quota of leaves which covered many defects. Individuals of the same species varied much in their resistance to damage. Injuries to flower buds were noted in some foreign species.

On the whole the hardy native American spruces (Picea) wintered well. The fine Sitka Spruce, *Picea sitchensis*, can not be grown here, but the very rare Brewer or Weeping Spruce, *Picea breweriana*, of the mountains of southern Oregon and northern California, will live but does not thrive. The single plant, now 7 feet high, in the Arboretum had most of its buds killed last winter, but some of the stronger terminal buds survived and have developed new growths of from one to two or three inches. Although beautiful in its native habitat, in cultivation it is a straggling plant difficult to grow and unworthy of planting in this climate. Some of the long-introduced foreign species wintered well. The Norway Spruce is bearing a good crop of cones and the trees show no winter injury. This condition may be due to the fact that the original seed came from a northern part of its range in Europe, rather than a southern district. The spruces which show greatest damage from the severity of the winter are those which have been collected in central and western China in the provinces of Hupeh and Szechuan. The latitude ranges from about 28° to 33°. Probably few interested people realize that the latitude of this Chinese collecting ground, which has been repeatedly explored to furnish plants for our northern gardens, largely corresponds to that of northern Florida and the southern half of Georgia. Florida ranges from a few feet above sea level over the most part to rarely 300 or 400 feet on the highest points. Southern Georgia averages higher than Florida, but much of the territory here considered is well under a thousand feet in altitude and rarely exceeds two thousand, although higher hills and mountains are more common above 33° of latitude. Trees or shrubs from the Florida and Georgia zones under notice would rarely be considered as worth introducing for permanency into our

northern states. The temperature of the same latitude in western China, however, is greatly lowered by the general altitude of the country, which is from one to two thousand feet on the lower levels to ten or twelve thousand feet or more in the higher mountains. However, the law which compensates latitude by altitude does not always work out evenly or satisfactorily. Precipitation, prevailing winds, geologic features, soil and other factors are influences to be considered. Estimation of latitude as related to altitude may be roughly stated, as in the allowance of one degree of latitude to 450 or 500 feet of altitude. As already stated, much depends upon other ecological considerations. The latitude of eastern Massachusetts may be stated as approximately ten degrees or 600 miles north of the latitude of central Szechuan. Although Kew Gardens, in England, are nearly 600 miles farther north than Boston, in a latitude corresponding to southern Labrador, the climate is wonderfully modified by the warm waters of the Gulf Stream. Late studies have shown that the dozen or fifteen supposedly new species and varieties of spruce recently brought from China may easily be reduced to less than half a dozen species, some of which had already been found by earlier collectors and been named. Some of these species or so-called species show very serious injury from the effects of the past winter. For all practical or ornamental purposes they would be generally worthless for eastern Massachusetts if we had occasional repetition of such a winter as that of 1934.

Picea asperata and its described forms has proved to be not dependable or desirable under such conditions. An examination of several trees at the end of summer showed that about half or more of the previous winter buds had failed to develop or to make any appreciable growth. Where such a large proportion of the buds are killed or stunted the surviving terminal or other buds often produce unusually long new shoots due to the concentration of growth into a few rather than many twigs. Under such circumstances the trees are likely to become permanently unsymmetrical. *Picea asperata* as a name for this species will probably disappear as a synonym, as it hardly differs from several other so-called species which have been brought from western China. It is clearly not adapted for successful plantings in regions with more severe winter climate than that prevailing at Boston, and even here we have seen that it is liable to serious damage in unusually severe years or situations, although there are trees in the vicinity where the plants are reported to have come through in good order. It may be that hardier races may yet be found in western China.

Picea balfouriana, from Szechuan, suffered so much damage from the severity of the past winter that it may be considered as unsafe to plant in this climate for permanent landscape effects. A tree 14 feet high showed all buds dead or badly checked. In midsummer the tree showed new leaves forming about the old dormant buds, but no new growths of twigs. A little further south or in mild or normal winters it may be attractive. It appears to be an older described species under a new name.

Picea purpurea was badly injured and is very unpromising for this region, although it may be a very desirable acquisition under less severe conditions.

Picea watsoniana, twelve feet high, had a very large proportion of its buds permanently blasted, a few escaping unhurt and now showing new extra long shoots. These extra vigorous survivors among the multitude of buds which have failed must eventually produce an unevenly developed and undesirable tree for northern gardens.

The true firs, belonging to the genus Abies, have long had a peculiar attraction for gardeners and landscape planters and there is naturally a particular

interest in all the species which are reported as hardy in our New England climate. We have few American species which thrive satisfactorily in the climate of Boston, probably the best being *Abies concolor* or White Fir of our Rocky Mountains. But to be hardy and satisfactory in New England the seed of this species must be procured from the drier, colder territory east of the Rocky Mountains, as in Colorado, for if grown from seed collected from west of the Rockies the results are far less satisfactory. This is true of most of the other splendid Pacific coast firs; they are too tender for satisfactory growth in central New England.

European firs, like the Nordmann Fir, *Abies nordmanniana*, and the Cilician Fir, *A. cilicica*, have long been grown here with much satisfaction. The past winter proved seriously injurious to both species. The injury took the form of causing the death of the hearts of a great many of the winter buds. The percentage of injury varied on different trees in different exposures. Usually on the most damaged trees some buds escaped. The result has been that by autumn, when all new length growths should have been completed for the season, the major part of the twigs and buds still appeared as they did the previous winter except that in some cases a few twisted green leaves developed at the sides of the dead buds, or new very short twigs were formed. The few leading buds which escaped injury produced abnormally long new shoots as a result of the failure of a majority of the buds to develop. The apparently dormant twigs were found developing scattered small buds in the axils of leaves. These may grow next spring and carry on growth a year late. The result is likely to produce very irregular and undesirable trees for ornamental purposes.

It was hoped that the introduction of firs from Japan and western China would add greatly to our available ornamental trees, but the experience of the past winter has shown that at least some risk from climatic changes is involved in using several of these species. They may appear to be doing well during a number of ordinary winters, and in favored situations, but a time may come when their behavior may prove very disappointing. The Japanese Nikko Fir, *Abies homolepis*, for example, on large trees on low ground, had a large proportion of buds winter killed, and the struggle to produce new buds and leaves was very apparent in late summer. If these latter survive and continue growth next year the result will probably be decidedly disappointing. On higher sheltered ground with good air drainage the trees show only a small amount of injury, although the conspicuous male flower buds, a third of an inch long, still remain hard and inert and are black and dead within. *Abies veitchii*, from Japan, considered one of the most beautiful of firs, was so damaged that gardeners may well be discouraged about planting much of it in localities with occasional very low temperatures. Recent studies of firs from western China seem to show that there are not so many species to be credited to that region as has been claimed. They did not endure the winter in a satisfactory way.

The larches (Larix) came through the winter in good order, except that in some cases the flower buds were destroyed. The behavior of the Japanese Umbrella Pine, *Sciadopitys verticillata*, in the Arboretum was interesting, inasmuch as out of six trees growing near together three retained their usual winter quota of leaves while three lost most of their foliage, but as the buds were still sound a new growth of leaves developed which partly recovered the seminakedness of the branches. These should have a full complement of foliage and attain normal appearance by the growth of another year.

The Bald Cypress, *Taxodium distichum*, of our southern states, in this

latitude usually loses the tips of branches and twigs in winter, but the defect is soon overcome by new growth. After the past winter this trouble was decidedly more apparent, but as the trunks and main limbs withstood the test they put forth belated new shoots and leaves. However, the trees are not ornamental.

Rather curiously, the Pond Cypress, *Taxodium ascendens,* which we have regarded as more tender than the other, as its general range is more southerly, came through the winter in fine condition and quickly produced its cover of light green foliage. As the two species are growing on the same northerly incline and within a few yards of each other the disparity in behavior was very interesting and unexpected.

The arbor vitaes (Thuja) behaved much as usual in other seasons, the giant western arbor vitae wintering wonderfully well. This was true also of the genus Chamaecyparis, commonly called cedar or cypress, names also applied to some other genera. Some injury was caused by browning of foliage and other minor injuries such as are frequently noticed after the average winter. Even the somewhat uncertain Port Orford Cedar or Lawson Cypress, *Chamaecyparis lawsoniana,* came through with apparently little injury on Hemlock Hill, although it makes poor growth on low ground. Some injury was noted on junipers (Juniperus), sometimes causing the premature shedding of minor twigs so that the trees or affected portions lost their clean greenness. But the branchlets usually appeared alive to near the tips, new growths appearing and giving promise that in another year the trees may present a more normal appearance. The dwarf spreading and the dwarf pyramidal junipers occasionally showed dead branches which probably succumbed after being weakened by other causes.

Incense Cedar, *Libocedrus decurrens,* 35 feet high, in the shelter of hemlocks, wintered much better than might have been expected, considering that it is a Pacific coast tree, west of the crest of the Rocky Mountains. The hardy race of Cedar of Lebanon, *Cedrus libanotica* or *C. libani,* introduced from Asia Minor, proved gratifyingly resistant to the unusual cold to which it was subjected. Some trees lost a considerable proportion of their foliage in the spring, giving them a very open and naked appearance, but as few leaf buds were injured beyond recovery new leaves soon appeared, so that by next year the trees will probably have returned to almost normal aspect. When first introduced here from Palestine, a couple of hundred miles further south, this species proved quite unsatisfactory.

For several successive years the Japanese Golden Larch, *Pseudolarix amabilis,* has flowered and fruited freely. This past winter the flower buds were destroyed by the extreme cold, so that this season the trees did not bear any of their interesting cones. The trees, however, were otherwise apparently uninjured, a fortunate circumstance, as the species is one of the most beautiful and interesting of hardy deciduous conifers.

The famous *Cryptomeria japonica,* of Japan and China, unfortunately has so far proved not well adapted to the climatic conditions of Boston, although it may be long persistent and attain some size. In the past winter trees 20 or 25 feet high had a large proportion of the weaker lateral twigs and leaves killed, but stronger buds at and near the ends of branches survived and carried on new growth.

The killing or partial killing of flower buds occurred on many species of conifers and other trees and shrubs in Boston and vicinity, although the plants may have appeared otherwise uninjured.

MAN MEDDLES WITH NATURE

By Dr. HARLEY J. VAN CLEAVE
PROFESSOR OF ZOOLOGY, UNIVERSITY OF ILLINOIS

WHEN our forefathers settled the American continent, nothing seemed more certain than that the wild life and the natural resources were limitless and inexhaustible. Within recent years new conditions have developed so rapidly that we have witnessed the exhaustion of the inexhaustible and have observed the limitless approach the vanishing point. There are many evidences that these changes are in large part due to man's interference with the orderly processes of nature. Man has meddled with everything and has attempted to substitute artificial human standards of economics for the laws of nature. He views the results in terms of conquest of the wilderness and boasts of the advance of his civilization, but many of the things that he has done may be branded as flagrant destruction of and unintelligent meddling with the affairs of nature. Himself a product of nature, civilized man stands in open defiance of the laws whose operation brought him into existence. Like an anarchist enjoying the protection and advantages of laws, his actions reveal a disregard for the very codes which prevent his destruction.

In the days of the pioneers, it was possible to live off the land without exacting any serious toll from the native resources. The humble demands of logs for cabins, for barns and for fuel made no inroad upon the primeval forests. Deer, rabbits, squirrels, prairie chickens and turkeys graced the tables of the pioneer without at any time endangering the existence of the species requisitioned. Even the buckskin breeches and moccasins, beaver skin caps and buffalo robes of the pioneer made no serious threat to the original wearers of those skins. However, as civilization pushed farther westward, as settlements replaced the isolated cabins of the frontier, a new set of conditions was introduced. In one or two generations, the seemingly limitless supply of wild life faced a definite crisis. Dozens of species were brought to the brink of extermination, while a few were forced over the edge. The passenger pigeon was wholly exterminated, while bison, antelope and deer were rapidly approaching the same fate. The price at which our race has bought its advancing frontier includes not alone the stern injustice dealt to the savage natives. An even greater inhumanity has been meted to the wild life which only by a stretch of the imagination stood in the way of human advancement. Those who have seen justice in stealing lands from the red man, because the white man could make better use of them, will continue to find justification for the extermination of all forms of wild life as a sacrifice to advancing human frontiers.

The problem of determining man's responsibility for the annihilation of wild life is far from simple. Furthermore, reparations demand deeper consideration than mere passage of laws. Restitution is not completed by setting apart agriculturally unprofitable waste-lands as sanctuaries for the vanishing species. The real solution touches vitally upon the whole social, economic and industrial organization and operations of the human race.

In most courts, summary justice is dealt to the ignorant alien who kills song birds for food. Even if esthetic and recreational values to man be disregarded, every school child knows that as seed-eaters and insect-destroyers the song birds have direct importance to

man far outweighing their worth as food. The public feels a surge of resentment toward the poacher, the game hog and the illegal fisherman. For some strange reason, indignation lies dormant in the public breast when the public is confronted with the charge of dumping sewage into the streams and of allowing the infant industries to sneak their industrial wastes into the waterways. We are inclined to make a very sharp distinction between the individual breaker of the civil law whose guilt may be measured in terms of the number of dead animals found in his possession and the public, under-cover desecrators of nature, whose crimes are condoned as unavoidable accessories to progress. At so many points, temporary human interests come into open conflict with the laws of nature that the two are in perpetual conflict. Almost without exception, the human interests win, but at a disgraceful cost when the sum total of human welfare is measured.

Many uninformed people have thought that with the advance of our frontiers the disappearance of wild life has been due solely to the slaughter and destruction of the native animals and plants. On the contrary, convincing evidences point to the indirect responsibility of man as well as to his direct program of extermination. Alterations of the natural environment are highly effective in bringing about extermination of the plants and animals which held title to the land before civilized man pressed his claim. It often becomes difficult to differentiate and to evaluate the relative responsibility of these two factors. Thus, for example, either relentless slaughter or destruction of the prairies would have been sufficient to bring about the destruction of the bison, but together their effect was cumulative. From most of the western plains country the bison was driven by wanton destruction before the plow had ruined the natural range on which the herds depended for grazing. Man's interests and those of the bison were incompatible. Even in nature there are many species which seem to be incompatible. The appearance of one means the disappearance of the other from a given territory, not because of open conflict between them but because the two are unable to live together. Man frequently renders biological conditions unfit for the continued existence of native creatures without being aware that he is responsible for any change. Much more frequent than the slaughter of the original inhabitants is the destruction of their feeding and breeding grounds by changes wrought by human occupation. These changes are often of a subtle biological nature which would pass unnoticed except for a scientific approach to an understanding of the diverse problems of conservation.

Few wild animals can survive contact with man and remain unchanged. Their habits are much more firmly fixed and actions are frequently more rigorously controlled from within than most of us realize. Many acts which we as human beings perform and interpret as evidence of intelligence are performed by other animals in an unvarying, unmodifiable manner, suggesting that they are reflexes or are possibly instinctive. We used to interpret the industry of the bee and the accuracy of the sting of the wasp in killing spiders and insects in terms of human intelligence, involving motives, but it requires only superficial study to reveal the fact that little intelligence and much of uncontrollable instinctive action here unite to give the impression of intelligent behavior. Many hundreds of animals starve annually in the presence of what seems to be adequate food supply because of their inability to substitute foods which to our human sense and dietetic understanding appear "just as good as" their natural foods. While we were going through that trying period of the world war perhaps we did not understand what life-giving value the train-

ing in acceptance of substitutes gave to us. Herds of deer have been known to starve when natural food on the native feeding range has been depleted, even though short journeys might have brought the herd into new territory with plentiful supply of natural forage.

One of the most serious problems challenging a program of wild life conservation in parks and sanctuaries of all sorts is the fact that conditions more favorable than those existing in nature lead to overpopulation. As a consequence, predatory animals tend to increase along with the multiplication of their prey. Here man steps in with a program of extermination of the predatory species. In eliminating the predators, he has approached the solution of one problem only to face a more serious one of overpopulation of the protected animals in the absence of the natural checks to overproduction. Man becomes the most important factor in the environment of any organism which directly or indirectly comes within his sphere of action. Even the forms of life which he aims to favor and to protect may become radically changed because of their contacts with man.

When man occupies a new area of the earth's surface, it is not a simple adjustment for the wild life to move on to an area unspoiled by human contacts. It is relatively easy to understand the disappearance of such large animals as deer and bison, when man kills them to satisfy his hunger and to provide shelter and even at times stoops to destruction for the gratification of the brute desire to kill. Unfortunately, the conspicuous changes in the fauna are but the beginnings of the modifications wrought by human occupation. Direct slaughter is no more surely an avenue toward extermination than is inability on the part of the native life to readjust to the new conditions imposed by man. As stated previously, destruction of suitable breeding and nesting sites is one of the most potent factors indirectly leading to the destruction of wild life. Yet, at the time, the individual is often unaware of the fact that he is guilty of desecrating nature. Biological relationships are too subtle and the public is too little trained in the sciences to have an understanding of the significant biological aspects of a program of conservation.

Some kinds of animals face man's severe influence upon the environment and survive. Even these rarely remain unchanged. The most frequent method of establishing a basis of relationship with man is by open challenge to man's right of occupation. This challenge may be supported by the fact that man's crops and stores provide conditions more favorable than any of the species ever experienced in nature. Regardless of whether the animal under consideration be a mouse in the pantry, a wolf in the sheepfold or an insect in the cultivated fields, it profits directly by human contact. Many animals are transformed by human contact from inconspicuous members of the wild life, fighting an uphill battle for mere existence, to prosperous competitors with man, challenging every human right and every step of human economic advance. These beings, which are not destroyed by the man-dominated environment, are not even degraded to the pauperized state which frequently marks domestication. Because life is made easier for them, they have more time for leisurely occupation of destroying human property. They become serious detriments to human welfare, and in popular parlance as well as in scientific usage are branded as pests. Man is apt to forget that his tampering with the affairs of nature has created the abnormal balance favoring these, his competitors. His disturbance of nature permits his foes to exist in wanton luxury, while for their kind any margin beyond mere existence is converted into increased numbers.

Frequently, animals find life so much

simpler under the conditions provided by man that they ultimately become more or less dependent upon human association. Chinch bugs in a cornfield have no need of thought for the morrow. Man, their benefactor, has set up conditions which enable them to devote their entire time to feeding instead of hunting for food plants. Natural limits to increase in number are wiped away and the chinch bug becomes a menace to the crops that made its life too simple. Rabbits and squirrels become more abundant in fields and orchards and in public parks than under the primitive conditions, for human protection grants almost limitless food supply and natural enemies are held in check. Bears in the Yellowstone National Park are becoming disgustingly civilized, preferring the garbage pits to the more laborious alternative of feeding upon honey, small animals and berries. Bluebirds, house-wrens, swifts and martins are examples of birds which have become largely dependent upon nesting sites provided by man. It is yet too early to predict what influence this dependence may impose upon birds of the future. The tendency toward domestication is extremely significant. Many conservationists are not aware of its influence in a program of conservation. State agencies, clubs and individuals annually spend large sums of money rearing quail and pheasants under barnyard conditions. When these semi-domesticated birds are liberated they fall easy prey to the hunter or to the wild predator because they lack the wariness characteristic of the wild stock.

In the foregoing paragraphs we have reviewed some aspects of man's responsibility for the changes affecting our native living things. Let us turn now to the attitude which civilized man holds toward these changes. There is no field of public interest in which there are more prevalent and wide-spread mistaken notions than in the thinking on problems of conservation. The average citizen interested in a program of conservation calculates solely in terms of moneys, laws and public sentiment. He acknowledges some debt to nature but views the damages in much the same light that he rates property damage. Repairs can be made if there is money enough to foot the bills. The economic, civic and educational aspects of conservation have frequently been stressed to the exclusion of some fundamental underlying principles that have their roots in the biological sciences. Many people have erred in the thought that money in sufficient sums, laws that are adequate and a public sentiment in support of law enforcement are the only requisites for the perpetuation of the remnants of our native wild life to all future generations. Viewed from this angle, conservation is built upon shifting human emotions and interests, never reaching the firm foundation of scientific fact which alone can give it stability and even relative permanence.

Societies are formed for the protection and perpetuation of certain kinds of wild life, ignoring the fact that all living things are but transient features on the face of the earth and oblivious of the fact that change is one of the few inescapable laws of the entire universe. In terms of total human experience, changes in the forms of life under conditions of nature are unbelievably slow. Only by projecting the thoughts backward into a past inconceivably remote do we begin to realize how incomprehensible is the age during which nature has been engendering the plant and animal life with which we are familiar. Long before man entered upon the scene of earth history, there were conspicuous changes marking as distinct the forms of life which in successive periods inhabited our globe. As we now piece together the broken fragments of the picture of the past, we see that thousands of actors in the pageant of life took their cues, trod

the boards in the drama of evolution and made unrecorded exits as the scene of one period drew to a close and the curtain of another rose to reveal a new cast of characters in new rôles with new habits fitting each to its surroundings.

Nature, so often viewed as a kindly mother of life, has been ruthless and wanton in her treatment of the individual. Evolutionary progress has been made possible only through the sacrifice of individuals in the blind struggle for endless change in the races of living beings. In rapid succession, entire species have been wiped out to make way for others, better suited to a changed environment and therefore better fitted to live. So great is the period of time and so profound are the changes that mark the transition from one era to another that the same species rarely bridged the gap between eras. Though these facts are generally known, in our human limitations we talk of perpetuating a given species when the entire history of life reveals the untenability of considering any species as permanent. For sake of sentiment, we plan for the perpetuation of redwoods, of bison, of antelope, though we know that in the plan of nature each species is but a transient. Even man who does the planning has no assurance that his race is more than another temporary participant in the pageant of the ages. Our concepts of time are relative. Individually, man thinks in terms of one lifetime. As a race, direct experience of time is limited to the few thousand years of human history. The geologists and astronomers have forced us to think in new concepts where a thousand years are as but a day and millions of years become the common unit for estimating periods of earth history.

In seeking the causes for changes in the forms of life upon the earth, the average person is apt to think that physical changes of the soil are entirely independent of living things. It is a well-known physiological fact that animals and plants themselves produce changes in their environment which eventually render the surroundings more suitable to other forms of life than to the organisms living there. A soft-wood forest in time becomes converted into a hard-wood, not by transmutation of the original trees but by climatic transitions and by changes in the soil, rendering it more readily adapted to the needs of hard-woods. Acorns and maple seeds, fortuitously introduced in such a woodland, find congenial conditions and grow, ultimately replacing the original trees when these reach old age and die. Thereby, one type of forest is gradually transformed into another largely through the agency of changes produced in the soil by living things.

Accompanying the changes in vegetation, animal life undergoes parallel modifications, for it is not accidental that certain kinds of trees and plants are found under a given set of physical conditions and that particular kinds of animals are almost invariably associated with certain types of vegetation. Hunters do not go to the cornfields to find squirrels, nor to the oak-hickory forest to shoot rabbits. The brook trout and the musky are not found in the same waters. In addition to its physical surroundings, every form of life has certain biological limits to its distribution, certain kinds of plants or animals with which it habitually associates. So intimately is the individual organism adjusted to its living environment that many biologists have come to consider that the individual plant or animal is not the natural unit of life. Since all living things in a given space comprise an integrated unit of life, representing a most sensitive balance between favorable and unfavorable influences, many students choose to adopt a distinctly sociological interpretation of life, viewing the individual as a subordinate part of a larger social system. Whenever

balance within the system is disturbed, new adjustments have always been imminent. Climatic changes, physical disturbances in the environment, elimination of one species and introduction of other species are among the most common disturbing factors necessitating readjustment. Sometimes new forms of life have been molded under the influence of altered conditions, and progressive evolution has followed. Sometimes the native species have been unable to make the necessary readjustments so that death of the individuals ultimately spelled the death of the race. Many animals and plants in the past have been unable to keep pace with the demands of a changing environment and in consequence entire groups, such as the dinosaurs and the native horses and camels, became exterminated and are now known only through their fossil remains.

We have reason to believe that the changes which necessitated readjustment and led to the ruthless extermination of those forms which failed to adapt themselves were, in most instances, extremely slow, requiring thousands or even millions of years. As a disturbing factor, creating changes inimical to the continuation of life as it exists in nature, man has been able to produce in a single generation changes that can be paralleled only by processes operating over long periods of geological time. Without qualification, civilized man is the most destructive influence that has ever been introduced to upset the delicate balance of reaction and interaction between organisms and their environment. Part of his disturbance may be credited as unavoidable, but in large measure it takes the form of either wilful or thoughtless destruction, in no manner advancing either the individual or social interests of man.

By wasteful lumbering methods, man devastates a forest, thereby putting an end to definite, orderly successional processes of nature which have been operating through thousands of years. Man destroys in a day what nature has required ages to accomplish. Rings in the stump of a fallen oak may give evidence that the three or four hundred years of its life outspan the total period of our history as a nation. But even this age, which the annual rings reveal, marks only the final period in a much longer series of preparatory stages leading up by long and tedious conditioning of the physical and biological environment in anticipation of that oak. One does not need to be intimately familiar with the aspen thickets of the cut-over country to appreciate the fact that destruction of a mature forest sets nature back to an early stage in biological succession.

When a forest is cut off, the animal life dependent upon and developed along with that forest disappears. Some of the large and active forms may be able to migrate to similar adjacent regions, but even there they upset the population balance and confront new problems in the struggle for existence. In speaking of the changes which accompany deforestation, it is not alone the large conspicuous animals that are affected. Insects, spiders, snails, even the earthworms and the countless myriads of smaller animals accustomed to forest conditions disappear when the trees are gone. Most of the species are replaced by a wholly different population. Even the lowly vegetation of the forest-floor becomes modified after the timber is gone. On recently cleared woodland it is a pathetic sight to observe the pining mandrakes, ferns and lady-slippers deprived of their inseparable companions in nature, the trees.

The tale is not completed when an inventory of the changes in plant and animal life has been taken. The loose forest soil is exposed to unaccustomed erosion and evaporation. Sun-baked humus no longer holds a reserve supply of water. Floods result. Publicity is given

to the economic losses and human suffering entailed by floods, but rarely a mention is made of the toll of native life. Rarely are we logical enough to place the responsibility on the shoulders of fellow men who destroy the natural flood preventives. We prefer to blame the river which has gone on a rampage rather than the citizen who in his greed has stolen the natural flood plains from the river and has robbed the river of its forests. Human responsibility for damages does not stop with the change in plant and animal life accompanying deforestation and loss of life and property in subsequent floods. The selfsame floods carry the surface soils into the streams, not alone reducing the value of the land by erosion but also destroying the lakes which act as catch-basins for the eroded soil and in time are transformed into mud holes and swamps. Here again a series of successional stages, relatively slow in nature, becomes unbelievably accelerated by human interference with nature. A pond or lake surrounded by cultivated fields rapidly passes through the successional stages of transformation to marsh and final obliteration, leaving nothing but a meandering stream. Even this final stage of nature is wiped from the face of the earth by conducting the water in underground tiles.

The agriculturalist and the economist may maintain that drainage of swamps and of back-water lakes is good economic practise. They may even be able to compute the enhanced value of the reclaimed land in terms of increased tillable soil. In this country, with overproduction staring us in the face as one of the most serious handicaps to economic recovery, we are beginning to realize that many types of land are better suited to reforestation than to cultivation. The economic returns of scientifically conducted aquiculture may be much greater than returns from agriculture on the same area. From afar we can diagnose the ills of China, recognizing that floods and famine are natural accompaniments of deforestation and removal of all ground cover. At close range our judgment seems to lose perspective, and relying on superior wisdom we proceed to practise deforestation and permit private enterprises to drain bottomland lakes. In this country, with few exceptions, reclamation projects which have endeavored to rob natural waterways have been financial failures to all except the promoters.

Thus, whether we view the land, the natural vegetation that grows on the land, the animal life which this vegetation shelters and in a sense selects and develops or the waters and their life, we find that human intervention produces changes in a few years which require ages for their consummation by nature unaided by man.

Before civilized man came onto the scene, all nature hung in a delicate state of equilibrium, a condition which students have chosen to call "the balance of nature." Changes, regardless of how large or how slight, were followed by readjustment. The old Malthusian doctrine operated with a vengeance. The inherent tendency for every species to produce more offspring than could possibly be sustained yielded the material upon which survival values for the fittest operated to maintain the balance of nature, not on absolutely even keel, but running in periodic waves. Elk and deer were held in check and were improved by limitation of suitable range and by natural enemies. A season of unusually favorable circumstances, resulting in excessive increase in the number of young and more than sufficient food supply, brought a temporary increase in the numbers of deer and other grazing and browsing animals. Such increases did not continue indefinitely, year after year. After a time came a period when predatory animals, which had prospered because of abundance of

their natural food, became relatively more numerous than their prey. Natural checks to excessive numbers were thus established. Over a period of years the population of each species represents a delicate balance or compromise between favorable and adverse conditions of the environment, and for each species both living and lifeless things go to make up that environment. The composite of these delicately balanced conditions for all forms in a given region results in establishing a sort of general balance or equilibrium for the whole area. Man with his ability to dominate his surroundings destroys this natural balance and in so doing opens a Pandora's box of troubles for himself. To satisfy his wants more readily, he long ago ceased from hunting for the scattered fruits and grains which his forebears sought and depended upon for nourishment. For his own convenience he now plants several hundreds of acres at a stretch in a single crop. In catering to his own convenience, he has at the same time made life easier and more certain for the hundreds of different organisms which had been dependent upon the scattered plants under conditions of nature. Without man willing it, these natural associates of his crop plants thrive to an extent never before possible for them and become competitors with man for the fruits of his labor.

To-day we have hundreds of species of insect pests, some of which challenge every advance made by the human race. Even some species of birds may become pests and many predaceous mammals interfere with man's program of meddling with nature.

When game animals are herded and protected on preserves and reservations, man has caused a serious disturbance of the laws of nature. Under crowded conditions, communicable diseases assume more serious proportions than they ever attain in nature. We have recently witnessed a sorry plight in the Jackson Hole country. There natural food supply is wholly inadequate to care for the elk which have multiplied excessively under their semi-domestic conditions, deprived of their natural checks to overproduction. Even more strikingly our government has been confronted by a serious problem in the Kaibab Forest and on other preserves where game has multiplied abnormally. With the unnatural population, predatory animals, such as coyotes, wolves and mountain lions, have been favored until governmental agencies have considered themselves forced to inaugurate a program of extermination. All this because we have lacked an appreciation of the natural laws and thereby have rendered the conditions of existence too favorable for the animals which we have sought to protect and at the same time too favorable for the natural enemies of the objects of our benefaction. This is a marked instance of a case where will, intent, legal enactment and financial support were all focused on a program of conservation. But the program has in a measure failed because due consideration has not been given to the natural biological aspects of the problem.

There are many other examples of failure of conservation measures traceable to insufficient consideration of facts, especially in many game and fish laws. With the best of intentions, state legislatures have in the past enacted laws providing closed seasons for the protection of game animals, birds and fishes. In many instances it has been discovered that these closed seasons have failed to coincide with the period of the year when the young are being produced or when eggs are being cared for. Few organisms pay particular attention to the calendar. The breeding season of the black bass varies from year to year, depending upon temperature of the water and a complex of variable factors which can not be expressed in terms of exact calendar dates. In some localities,

many breeding fish have been caught from their nests because a fixed date intended for their protection failed to coincide with the advance of the season.

One of the gestures in the name of conservation which is frequently devoid of any biological background in its application is the attempt at increasing the population of wild life by planting fish and by breeding game birds and animals. As administered by most agencies interested in these activities such work becomes largely a political matter in which no direct ends above political favor are sought. There is no merit in liberating quail or pheasants on farms where no suitable cover or feeding grounds are provided. There is no biological justification in dumping a carload of fish in a stream which is wholly unfitted for maintaining fish life. When a stream becomes barren of fish it is relatively easy to satisfy the public by restocking it. No self-respecting political agent of the public would dare to inform his public that their streams are so rotten with sewage that no fish with a standard of living above that of a carp could take lodging in them. Such information belongs to the pedantic biologists and has no place in the thinking or program of the political conservationist.

In a few generations we have seen the rivers which sheltered the finest game fish desecrated and turned into open sewers unfit for supporting life or for giving recreational enjoyment. Many have condoned this act as one of inevitable necessity, but to the biologist and to the sanitary engineer no legitimate excuse may be offered. Stream pollution is a crime against nature and against society for which man has paid dearly and will continue to pay even more dearly in the future if the evil is not abated. When cities depend upon water supply from rivers, stream pollution becomes a very serious problem. Where cities are far separated, the wastes of one have the opportunity of becoming naturally purified before the stream reaches the next village. With increased loads of pollution, due to increased size of the civic units, and with the increased density of population, natural chemical and biological processes are incapable of breaking down the wastes from cities up stream before the river is called upon to provide the water supply for cities farther down. The obvious result is that the less fortunate city is compelled either to use the sewage of the other cities or to install expensive systems of treatment to render the sewage safe for domestic and industrial purposes. Responsibility for damage to the water supply should be attached to its source. In this age, no city or organization has the right to impose on others the cost and responsibility for purification of its wastes. From the point of view of justice and of public health, sewage treatment is one of the prime obligations which each community must meet ultimately. On the biological side, the problems of pollution run into incomprehensible figures of economic wastes and deplorable faunal losses. In a few weeks by domestic and industrial pollution man exterminates all the valued animal life from natural waters to an extent equaled only by the ages required for similar losses in nature.

In a number of places throughout the foregoing paragraphs reference has been made to the balance or tendency toward equilibrium in nature and the disturbing elements which, destroying equilibrium, superimpose a definite cyclic phenomenon over the general tendency to maintain a level. Similar cyclic phenomena may be noted in regard to man's disturbances of the natural order and these offer a hopeful note sounding above the discord of man's inhumanity to his fellow creatures. The severity of man's influence upon the living things of his environment seems to undergo a definite progressive change as civilization ad-

vances. The first broad contacts of man and nature are severe and the severity increases up to or just short of the vanishing point for many of the native species. This may mark the turning point and, in the following readjustment, conditions again become favorable for the remnants of wild life. Let us trace this cycle in the older, long settled regions of our country. In the eastern states the first contacts of the settler imposed few changes upon the life of the region. With introduction of intensive systems of agriculture and increased density of population, conditions became progressively more adverse for the native life until local extermination resulted. The same spirit of wantonness which has marred man's attitude toward the native wild life has characterized his disregard for the soil. In many of the older parts of the country, the soil has become exhausted and the farms have been abandoned. On these abandoned lands a new cycle of life is becoming established. Under conditions where adequate protection by law is offered, game animals and other forms of wild life increase to an abundance rivaling the primeval condition. Some scientists have seriously doubted the permanence of the human race. If it is true that the evidences of organic decline and potentiality of self-destruction through the creation of machines and discovery of destructive agencies may lead to man's downfall as a race, it is possible that nature in the future may be able to rebuild herself and that man's interference with her plans may prove to be another one of the transient features in the plan of the universe.

Throughout this discussion, I have intentionally set man and the conditions which he creates over against nature. Some might object to this as illogical and maintain that man as a product of nature should not be set in antithesis to the remainder of the natural environment of our native wild life. Through his use of machinery and his ability to modify the environment to meet his own needs, man introduces a whole new code of laws apart from and all too often in direct conflict with natural law. It is on this ground that man as an influence upon nature, of which he is an integral part, is set over against nature as it operates when freed from human interference. By his contacts, man accelerates changes which take infinitely longer periods of time without his intervention. In the natural environment civilized man is a catalyst producing most profound reactions. Usually these reactions have been to the detriment of most forms of life with which he comes into contact. These destructive agencies are capable of reversal. It is entirely possible for human society through adequate recognition of natural laws to avert extermination of the remnants of our vanishing wild life and to bring back clean streams with their characteristic life.

As much as our federal and state governments have done toward setting aside refuges and sanctuaries in our national parks and forests and in the states parks and preserves, only a beginning has been made looking toward restitution of conditions. No program of conservation can ever attain the full measure of its ends until complete recognition is given to the body of underlying scientific facts which elevate conservation from the ranks of the political system.

Meddling, even that growing out of the best of intentions, must be replaced by intelligent understanding and actions before conservation may become a reality.

WHAT PREVENTS SOCIAL PROGRESS?

By Dr. DWIGHT SANDERSON

PROFESSOR OF RURAL SOCIAL ORGANIZATION, CORNELL UNIVERSITY

I. Science and Invention

As they contemplate the muddle of human affairs in the world to-day, a chief question in the minds of all thinking people is—"Why, with such wonderful inventions as science has made possible, have we not been able to utilize science in bettering our human relations? Why can not science produce social as well as material progress?" Obviously, we have made considerable advance in the art of living together, in spite of the feudal domination of our large cities by gunmen and racketeers. Our grandfathers abolished human slavery, the present generation has largely stopped child labor, hours of industrial workers have been shortened, a rapid increase has occurred in high-school education, play and recreation have increased, and there has been rapid improvement in medical care and health facilities. But with a superabundance of goods thousands of able-bodied, self-respecting people are cold and hungry, and life is chaotic. If science can invent machines and processes which make it possible to produce all the goods necessary in a much shorter work-day, as the engineers assure us is now possible, why can not science also show us how to adjust our human relations so that we can all have a chance to enjoy the advantages which it has made available?

I have no panaceas, but I believe that by analysis we may secure a better understanding of what is involved in social progress and how it may be achieved. Nor shall I attempt to define the term "social progress," which I shall use in a common-sense manner. If we think of the advantages we have in the use of electricity, radio, automobiles and the multitudes of modern inventions as social progress, it is obvious that science has done much to lighten labor and make life easier and more enjoyable. But when we study the present economic cataclysm of the world, we wonder whether all these things have really contributed essentially to progress in our human relations.

Even before the technologists forced it upon our attention, it was apparent to most of us that science and invention have created a new world with such rapidity that mankind has not been able to adjust its methods of living so as to advance and preserve the general welfare. Science and invention—including discovery—are, therefore, chiefly responsible for our present situation. It is unnecessary to recount how recent inventions have revolutionized our environment in the present century, for that is known by every child. These new inventions tend to dominate our mode of life and to set the standard of our values. Instead of a home or children, many prefer a better automobile. On the other hand, in many ways we have not adjusted our old habits to modern inventions. Rural people go twenty miles to see moving pictures by means of the automobile, without a thought; but these same people cling to the open country church and the one-room schoolhouse. Inventions have made our cities possible and city life has brought many changes in the mode of living, but most of the customs and attitudes of the average city person have been largely determined by the rural environment from which he came. Inventions in many ways determine and dominate human relations, but they also create new values which change our social attitudes. Thus railroads created the cities, but automo-

biles are now taking people into the country and are giving them a new appreciation of nature. Cities and modern methods of communication made advertising profitable, but city people who wish to see the beauty of the country resent the interference of huge billboards and are commencing to demand legislation which will do away with them. On the other hand, we have not learned how to prevent the slaughter of the innocents by automobile accidents, which cause more deaths and injuries every year than our troops incurred in the world war.

Why, then, if science has been able to give us such marvelous material inventions and discoveries, so that we live in a material environment beyond the dreams of Jules Verne and Edward Bellamy, can not science give us social inventions which will enable us to solve the relations of capital and labor, the difficulties of the farmer in his efforts to maintain a worthy rural civilization, the money and banking problems, and to enjoy international peace instead of spending most of our national budgets in the insanity of war?

If you will but think for a moment how the methods of science have created the material inventions which we now enjoy, it will be apparent why science has not made equal progress in social inventions. In the first place, the inventions and discoveries of scientists are not mere creations of the brilliant imagination of some individual genius. Every major invention or discovery is but the recombination of facts which hundreds and thousands of workers in the physical and biological sciences have laboriously brought together into a systematic body of knowledge during the past centuries. In the report on "Recent Social Trends," Professor W. F. Ogburn says: "An invention cannot be made unless the elements which form its base are in existence. The Greeks with all their intellectual powers could not invent the airplane, because they did not have the gas engine and their supporting devices. The larger the number of elements in a culture, the more numerous the inventions. Their growth seems to be somewhat like compound interest; the bigger the principal, the larger the interest." Recently the possibilities of scientific discovery have been so apparent that large corporations and private institutions support huge laboratories with large staffs of trained scientists who are wholly engaged in research.

On the other hand, the social sciences, economics, political science, sociology, anthropology and psychology, were born only at the close of the past century, although many of their ideas go back to thinkers of ancient Greece. There have been no such facilities for research in the social sciences as in the physical and biological sciences, for we have not become convinced that science can aid us in solving our social problems. A generation ago the older type of manufacturer was running his business largely by rule of thumb and made little use of science. To-day he can not compete without the aid of scientific experts.

More important, however, than the lack of scientific research and a consequent body of scientific knowledge with regard to human relations comparable to that which has been created in the physical and biological sciences, is the fact that inventions and discoveries of the physical sciences may be manufactured by individuals and corporations for *profit*. Social inventions and discoveries, on the other hand, yield no immediate profit to any particular individual, but are created for the common good. There is no pecuniary reward for the social scientist, and no immediate profit to any one in the use of his discoveries. On the contrary, social inventions which may ensure the general welfare usually are in opposition to the profits which some particular class or group of men have been making. They naturally oppose any change in the existing organiza-

tion of society and persuade the masses of the people that the discoveries of the social scientist are mere vagaries and academic theories, or they seek to arouse antipathy by branding them "pink." Many of you can remember, as I can, when intelligent people actively debated whether the microbe theory was true. It was an academic theory. But to-day our whole system of sanitation and medical science is largely due to the discoveries of bacteriologists.

Not only is there no immediate profit to the individual in the discoveries of social science, and frequently an opposition to vested interests, but there is an emotional attachment to our habitual ways of human association which makes it difficult for us to change them and which makes us exceedingly conservative with regard to discoveries in social science. We can see the advantages of an automobile; we can try it out, and if we like it, we buy one and it is nobody's business, so long as we do not have an accident. But we have an attachment for the church, the school, the family, our local government, our way of doing business, which is not so easily overcome as changing from a buggy to an automobile. Furthermore, in these forms of human relations and social organization many other individuals are involved and we can not as individuals adopt a new social invention.

II. The Opposition to Social Inventions

It is evident, therefore, that the adoption of social inventions or the discoveries of social science must await a process of education until the people concerned are convinced of their value.

This principle has been so clearly stated by my colleagues, Professors G. F. Warren and Frank A. Pearson, in the preface to their recent book on "Prices," that it may well be quoted as an illustration. "One reason," they say, "why progress in production is more rapid than monetary progress [and please remember that money is a social invention] is that production is subject to individual experimentation. The individual who has a new idea tries it out, even though he is ridiculed by the public. If the idea works, the successful demonstration hastens general adoption. Monetary progress can come only by legislation. It can proceed only as fast as popular education and vested interests that would be temporarily inconvenienced allow it to go."

By this time I hear some reader asking, Just what does he mean by social invention? We know such inventions as the telephone and the radio, the gas engine and the airplane, but what are social inventions? Social inventions are those which are used by society or groups of people rather than by individual persons. They are not material things, but are new ways of human association whereby definite services and functions can be performed which were not possible under the previous forms of social organization. The corporation is an excellent example and has so revolutionized our economic life that to-day we live in the age of the corporation, just as the people of medieval Europe lived in the Feudal Age. The corporation is a legal institution, but it is primarily a social invention. We are just commencing to get over the hate of corporations which was the common attitude in the days of our grandfathers, for this new creature of the law was able to do many things which individuals could not and it was felt that it put the individual at a disadvantage. That there was warrant for this feeling is confirmed by the history of the growth of corporations. A recent book by Professors Berle and Means of Columbia University on "The Modern Corporation and Private Property" informs us that the 200 largest corporations in this country have assets of $81,000,000,000, or 22 per cent. of the total wealth of the United

States. Obviously, we have some very real problems in the control of corporations so that they may best serve the general welfare rather than merely make profits for their stockholders, but no one would advocate doing away with them, for they have shown their ability to perform many services which we could not have had without their invention.

In quite a different field of human activity the Sunday School when it was first established in the beginning of the nineteenth century was certainly a social invention, as was its contemporary the public day school. Both of these new institutions were violently opposed by the conservative people of those days as being entirely unnecessary and as being inimical to the general welfare. The public school was declared to be a most dangerous socialistic institution, and the Sunday School ran counter to the current theology of those days and has ever been an institution of the laity rather than of the clergy.

Cooperative societies of all sorts are another type of social invention, differing from the corporation in that the profits or savings are divided among those participating in the business rather than by the stockholders. Consumers' cooperation has never achieved the success in this country that it has in Great Britain and Europe, but in Great Britain it has the same position in the retail trade as our largest systems of chain stores. Commencing in 1844 with the Rochdale Equitable Pioneers' Society, this movement has grown until in 1929 the cooperative retail stores in Great Britain did a business of over one billion dollars, and produced their own goods through manufacturing or agriculture to the value of over $300,000,000. In the United States cooperative associations for marketing farm products have made a rapid growth in the present century and in some years their business has amounted to as much as $2,500,000,000 or not far from one quarter of the annual sales of farm produce. Both cooperative consumers and cooperative marketing associations were violently opposed by private dealers and corporate business concerns, and only recently in this country have they won the recognition and support of the government.

Other social inventions which may be mentioned as illustrations are community chests for the support of social welfare organizations, juvenile or children's courts, the direct primary, 4–H Clubs, clinics of all sorts, mothers' pensions, workmen's compensation, the visiting teacher, social settlements, group insurance and the Federal Reserve System. All these, and a host of others, embody essentially new combinations of old forms of human association, and are just as truly inventions as any of those produced in factories.

All these social inventions have been welcomed by progressive and public-spirited individuals, but in most cases a few of those who saw the advantages of the new invention worked for years against the strongest opposition until they were able to convince the majority that it should be given a trial. What a contrast to the marketing of an invention like the radio, for which there was such an immediate demand from individuals that manufacturers were unable to keep up with their orders. Physical inventions may be adopted by individuals, but social inventions must be accepted collectively.

However, after they have once been adopted and become established social inventions become social institutions and a certain sanctity is attributed to them which arises both from use and from the fear that any change would endanger the established rights and relationships. Money is a good example of how a social invention has become sacrosanct. In an address before the American Farm Bureau Federation Dr. G. F. Warren expressed this when he said: "The 'money illusion' is as thoroughly domi-

nant in this generation as was the illusion of the flat earth about which the sun revolved in the time of Galileo. It is almost as dangerous for an economist to challenge the money illusion as it was for Galileo to threaten the foundations of civilization by saying that the earth revolved."

It is this emotional attachment to old ways and fear of experimenting with new ones, and the fact that social inventions must be adopted by the many rather than by individuals, which makes it impossible for social inventions, however rational or worthy, to be adopted suddenly. Many a seemingly good law has been unenforced or has been repealed because the mass of the citizens were not as ready for it as the progressive and intelligent leaders who sponsored it. The acceptance of social inventions involves new social attitudes and really new ideas, both of which are painful. Social inventions may be for the general welfare, but the average individual is usually more concerned with his own welfare and that of his family, and only occasionally or under dire pressure, such as occurs in times of war and such crises as the present economic situation, is he forced to see that his own welfare is bound up with that of others.

It is evident, therefore, that social inventions will find a welcome only when the old ways have become outworn and fail to meet the existing situation, and when the individual finds that his personal welfare can be obtained only through new methods which will reestablish the general welfare.

III. Individualism vs. Social Welfare

In commercial language, the "sales resistance" to social inventions is very great and is more difficult to overcome with a group than with an individual. Only occasionally do crises arise in which one finds that his own welfare can be obtained only through changes which ensure the general welfare.

Thus arises the paradox of what seems to be a conflict between the welfare of the individual and the welfare of society, which in one form or another is as old as the human race. Social progress depends upon some resolution of this conflict of the interests of the individual and the welfare of society.

The last century and a half has been an era which glorified individualism. The American and French Revolutions were not merely political. Their slogans of "Liberty and Equality" were aimed not only at tyrannical governments but expressed the desire of the common man to be able to carve out his own destiny, freed from the social and economic restrictions of aristocracy and the privileged classes. In America these ideas literally had a fertile soil in which to flourish, for free land made it possible for the people to act upon them in securing a new economic independence. Both the political ideals and the conditions of life of the pioneer bred independence and an emphasis upon rights rather than upon duties. The latter developed only as joint action became increasingly necessary with a denser population. The whole philosophy of the times was one of individualism and *laissez-faire*, which very naturally took root in the dispersed settlements with an abundance of free land beyond them. Not only free land, but abundant natural resources for exploitation and the numerous scientific inventions which made possible the manufacture of new goods encouraged and rewarded individual initiative, and there seemed to be no bounds to individual achievement.

To-day the situation is entirely changed and although we still cherish and admire a worthy individualism, we are compelled to admit that it does not have the opportunity that it had a century ago. To-day the average individual is no longer free to carve out his own destiny as could the pioneers in agriculture and industry.

Due to the rapid growth of cities and

better means of communication and transportation, the complexities of modern civilization have brought about an interdependence of our whole economic life, which forces us to consider how the needs and interests of the individual may be satisfied by social inventions which will better ensure the common welfare upon which he is dependent. Free land will no longer give the farmer a living, for he is dependent upon markets and better means of marketing in order to secure the goods which his present higher standard of living demands. The workman can no longer choose his job, but is dependent upon the policies of large corporations and he must belong to an organization by means of which he can bargain with them if he is to maintain his right to a reasonable wage. Even technical or professional skill is no guarantee of a living; witness the thousands of highly skilled professional musicians who are unemployed because of the mechanical production of music by the moving picture.

To-day individualism may still be an ideal, but it does not enable the individual to meet his needs or satisfy his desires as it did a century ago. The farmer is compelled to join cooperative marketing associations if he is to market his produce to advantage. He no longer raises merely what he needs for his own consumption, but he grows what the market demands and the kinds of crops which his neighbors grow so that there may be a sufficient volume of product and that it may be so standardized, packed and processed as to make it marketable to the best advantage. The industrial workman must belong to a trade union if he is to have any protection with regard to wages or working conditions. The local merchant must associate himself with others in buying pools so as to compete with the chain store, and even the manufacturer is forced to join trade associations and agreements in order to protect his interests.

Not only this, but with the increasing interdependence of commerce and industry we have become painfully aware that anything which affects one class, the city or the open farming country, affects the other, and that the welfare of the individual is increasingly dependent upon the common welfare.

Does this mean that we must abandon individualism and that there is no merit in the individual initiative which has been so extolled as the basis of American progress? By no means. Without individualism life would lose interest, society would be reduced to a dead level, and there would be little chance for invention or progress, either material or social. But there is a difference between the individualism which is self-centered and which seeks only its own immediate interests and the individualism which finds its achievement and satisfaction in serving the common welfare. The welfare of the individual and of society are not necessarily conflicting, and social progress has never been and never will be obtained except through the devotion of individuals who see that a satisfactory individualism is possible only under a social order which ensures true freedom and justice to all. In the past we have emphasized the rights of the individual. In the future if those rights are to be secured, we shall have to give more emphasis to the duties of the individual. This has been well expressed by Miss Mary Follett in her book "The New State," where she says: "The history of democracy has been the history of the steady growth toward individualism. The hope of democracy rests on the individual. It is all one whether we say that democracy is the development of the social consciousness, or that democracy is the development of individualism; until we have become in some degree socially conscious we shall not realize the value of the individual" (p. 162).

"Yes," you say, "we agree with your platitudes, but granting all that, and although social progress is probably de-

sirable, just how will it get us out of our present difficulties?'' The answer is that any adequate or even partial solution of our present economic and social problems will be a step in social progress. It will depend first upon our being willing to abandon some of our old concepts of self-centered individualism and our ability to see that only through sacrificing what we have conceived to be the inalienable rights of the few will we be able to secure the rights and opportunities of the many. The present economic and social disorganization forces us to take such an attitude, whether we will or not, just as we are forced to place the common welfare first in a time of war. But this is not enough. How to win a war or how to conquer economic disorganization is a technical problem and can not be solved by any amount of human devotion and good will. We face new issues concerning which the wisest and most devoted of our leaders can do no more than utilize the best knowledge available. But even if their solutions be correct, the answer will involve new social inventions, new ways of economic and social organization, the success of which will largely depend upon whether the rank and file of us common citizens understand them and are willing to wholeheartedly and fairly try out the experiment; for the determination of the value of any social invention is always an experiment. So we come to the conclusion that under a democratic form of government, unless we are to abandon our ideals of democracy, if new social inventions which are necessary for the general welfare are to be utilized, their success will largely depend upon an adequate understanding of what is involved and why the interests of each individual citizen, and hence the good of all, will be obtained through them. We are forced then to the conclusion that social inventions will succeed only as the people concerned in them are educated to understand the various factors involved and the nature of the advantages which they will secure. True social progress can go no faster than the general education of the people concerned. One reason that social progress can no longer be stopped is the rapid increase in high-school education in this country during the present century. One of the cardinal tenets of our American belief in democracy has been that it must rest upon the education of the people. The theory is sound, but the mere education of the children and youth in the use of intellectual tools is not sufficient for the preservation of democracy to-day. We have come to a time when the schooling which we received in our youth, based on the experience of previous generations, is no longer adequate to solve the problems of a new and ever-changing environment. We need a new type of individualism which sees its opportunity in the common welfare, but to succeed in this aim, men must be ever re-educating themselves to understand new problems as they arise.

IV. Education versus Democracy

So we come to the problem of ''Education versus Democracy.'' Not that we disbelieve in education for democracy, or that there is a real antithesis between them, but that democracy without education is impotent and may defeat its own desires.

In the nineteenth century we seemed to have a naïve faith in a sort of Jacksonian democracy; that universal suffrage would ensure right decisions and prove the merits of political equality. Although probably few of us would vote to abandon universal suffrage, yet we have become disillusioned as to its efficacy for good government. Science has confirmed human experience that men are not equal by nature or training, and that, lacking knowledge of the issues, the number of votes cast does not ensure a wise decision. Nor are we so sure that political equality gives us democracy, for we find that democracy

involves equality of opportunity, and that there is no equality of opportunity without economic democracy; business may manipulate politics.

It is not necessary that we attempt any exact definition of democracy, although it may be useful to gain some notion of what we mean by the term, for it undoubtedly forms one of our criteria of social progress. Harold Laski says that the essence of democracy is in "a demand that the system of power be erected upon the similarities and not the differences of men." Fifteen years ago Dr. Liberty Hyde Bailey wrote a little book entitled "What Is Democracy?" in which he gives us the spirit of democracy so clearly that I quote a few paragraphs (pp. 36–42):

> Democracy [he says] is primarily a sentiment—a sentiment of personality. It is the expression of the feeling that every person, whatever his birth or occupation, shall develop the ability and have the opportunity to take part. Its motive is individualism on the one hand and voluntary public service on the other —the welfare and development of the individual and of all individuals. . . .
>
> If the person is to be placed in the most advantageous conditions and environment, so will he desire a similar privilege for his neighbor and voluntarily assume the responsibility of which I speak. The yielding of advantage to another, the giving up of granted "rights," that another may have a larger life, are in the very essence of the democratic state.
>
> Responsibility, not freedom, is the key in democracy—responsibility for one's self, for the good of the neighbor, for the welfare of the Demos. Until every citizen feels this responsibility as an inescapable personal obligation, there is no complete democracy. . . .
>
> I find the root of democracy in spiritual religion rather than in political freedom or organized industrial efficiency. Democracy is a spiritual power or product of a people.

Laski's phrase "a system of power" probably can not be achieved upon a democratic basis without the attitude of personal responsibility which Bailey describes. However our ideas of just what is democracy may vary, we hold to it as one of our basic ideals and as a large factor in social progress.

Half a century ago there was a general assumption that universal education was essential for democracy and that education would ensure a wise choice of officials and decisions of public policy. Although there has been a gain in this direction, the results have by no means fulfilled the hope of the political effect of the public school system. There are several reasons for this. First, education was too narrowly conceived as being a training which would give the individual intellectual tools for making a living; it tended to be individualistic. Secondly, although the idea of education for citizenship has been current for some years, for the most part it assumed that an intellectual understanding of certain facts of government would ensure the desired behavior. Only recently have educators learned that behavior is governed by feelings and attitudes more than by intelligence, and that these are developed through experience more than by rational thought. But even if education for citizenship in our public schools had been all that might be desired, it would not have enabled the present generation to deal with the problems of public policy with which it is now confronted. The fact is that changes in our environment occur so rapidly that it is impossible for education to anticipate the social and economic problems which will arise within the life of one generation. How can education anticipate the effects of such an invention as radio?

To-day the education of children and youth *for* life is not enough, for life is changing all the time. The educative process must go on *through* life. If parents are to be of any help in the educational process of their children to-day, they can not rely on what they learned in school or college, but they must be informed on the latest knowledge. Obviously we can not go to school all our lives, but it is possible to devise a system of adult education which will enable men and women to study current prob-

lems of all sorts so that they may gain accurate knowledge concerning them and form their own opinions, or that they may become convinced that some of these problems are subjects which can be solved only by experts.

Nor need this process of adult education be chiefly an affair of the schools or of the formal educational system. Much of the best work that is now being done in adult education is by extension work in agriculture and home economics through the farm and home bureaus, through university extension groups, through parent teacher associations, child study clubs, granges, and similar groups. In the next generation we shall have to have a very considerable increase of agencies qualified to give expert assistance in the promotion and guidance of such more or less informal study groups. Through such a system we might continue our education so that we could know whether to accept or reject new social inventions, and if we accept them, to participate in them in such a way as to make possible their success. Democracy and social progress can develop no faster than the education of the people, and to-day their education for the immediate problems before them can not be anticipated in the schools or colleges. Who could have foreseen before the world war that we should become a creditor instead of a debtor nation and that the collection of war debts would involve us in the present international situation? Yet having the situation, what means are there for effectively educating our adult population concerning these matters, which are not controlled as political propaganda?

Nor is this principle that education is essential for social progress peculiar to matters related to government. It applies equally to non-governmental organizations. For instance, the social invention which has meant most to agriculture is the cooperative marketing association. Where the membership has been educated as to the facts and principles of the business matters involved, powerful and sound organizations have been built up; but where the membership has been secured by emotional pressure and the members have been ignorant of the methods of their organizations and the technical issues involved, the organizations have been short-lived.

There is no magical formula for creating social progress any more than for building automobiles. The automobile is the product of vast amounts of scientific research and technical efficiency, by people who know. Social inventions which will ensure a larger degree of social welfare likewise depend upon the scientific research of the inventor and the technical efficiency of the operator, but the parts of the new organization are human beings in a new social relationship, and if these elements of the new invention are ignorant of the rôle which they must play in order that it may function, it is doomed to failure unless they can be educated to give intelligent participation.

As Laski has indicated, the achievement of Democracy depends upon the control of power and is indeed merely a form for the social control of power. Power may be generated and controlled with beneficient effect, as in the electric current which lights our homes, or it may burst forth malevolently, as does the bolt of lightning which carries destruction. Uncontrolled power results in social disorganization, whether it be by the anarchist's bomb or by the manufacturer throwing thousands of men out of work because it is more profitable for his stockholders to do so. The democratic form of power resides in an intelligent public opinion, in an understanding of social problems as a result of education and in an attitude of finding personal welfare in the common good rather than at its expense.

Certain types of social progress which depend upon the power of authority are

possible under absolutism, fascism or communism; but social progress under a democracy is dependent upon education.

V. Planning Social Progress

In addition to all these factors, a chief reason why social progress lags behind material progress is that the latter is planned, whereas social progress is largely a product of social reform, an effort to correct social maladjustments rather than to prevent them by foresight. To-day, there is a peculiar need for social planning because material progress changes the social situation and disrupts our established human relations so rapidly that human relations tend to drift in its wake.

After ably analyzing the causes of the disorganization of our national life and culture and pointing out that "the spiritual values of life are among the most profound of those affected by developments in technology and organization," the President's Committee on Social Trends concludes its summary report with a convincing plea for the necessity of social planning:

> The alternative to constructive social initiative may conceivably be a prolongation of the policy of drift and some readjustment as time goes on. More definite alternatives, however, are urged by dictatorial systems in which the factors of force and violence loom large. In such cases the basic decisions are frankly imposed by power groups, and violence may subordinate technical intelligence in social guidance.
>
> Unless there can be a more impressive integration of social skills and fusing of social purposes than is revealed by recent trends, there can be no assurance that these alternatives with their accompaniments of violent revolution, dark periods of serious repression of libertarian and democratic forms, the proscription and loss of many useful elements of the present productive system, can be averted.

Finally, it concludes:

> Fully realizing its mission, the Committee does not wish to assume an attitude of alarmist irresponsibility, but on the other hand it would be highly negligent to gloss over the stark and bitter realities of the social situation, and to ignore the imminent perils in further advance of our heavy technical machinery over crumbling roads and shaking bridges. There are times when silence is not neutrality, but assent.

These are courageous words not of radical agitators but of a committee of six of our most eminent social scientists appointed by President Hoover who form their conclusion from the studies of hundreds of the best social scientists in the country. Evidently there is immediate need of planning if we are to have social progress rather than social chaos.

What, then, should be the procedure in planning for social progress? I can but briefly outline the essential steps.

First, we must have the facts. This involves research in social science comparable to that now made in the physical and biological sciences. As yet we have but a few bureaus of municipal research and various research bureaus of state and federal governments, all of which are considerably hampered by political considerations. As such research in social science is for the benefit of all rather than for the few, it will need to be supported by public taxation or by private endowment, for one of the essentials of any valid social research is that it must be free. It is difficult to twist the facts of chemistry, for they can be verified by laboratory experiments, but the findings of social science are not so readily verifiable and are always subject to the social pressure of interested parties.

Secondly, we shall require social inventions based upon the discoveries of social science. The difficulty and importance of social invention has already been discussed.

Thirdly, we shall need a new process of adult education which will inform the people of the facts, which will enable them to make wise decisions in the choice of social inventions and which will make the success of these social inventions possible through the intelligent participation of those concerned in them.

Fourthly, we shall need a new definition of our objectives, a new conception of what is involved in such terms as "Democracy" and "Social Welfare," and a beginning at the resolution of the conflicting interests involved.

Finally will come a definite process of social planning which will seek to relate physical and social inventions to our probable future needs, carried on by groups of technical experts and by representatives of the various interests involved and of the general public. There is, as yet, no formula for social planning. The most important immediate step is to come to the conviction that social planning is necessary and to recognize that although mistakes will undoubtedly be made, it is possible to learn how to plan for social progress as well as for the improvement of our physical environment.

Social planning has already become an increasingly important phase of city and regional planning. Recent examples of planning are the land utilization survey of the State of New York as a basis for its reforestation policy, and President Roosevelt's Tennessee Valley Project, both of which involve social planning.

How far shall we go in planning for social progress? What shall be planned? Will social planning involve all phases of life? These are questions which can not be answered dogmatically. Wisdom would indicate a pragmatic procedure rather than following doctrinaire theories. We do not want the excessive regimentation of life involved when all life is planned, as under communism, but we must plan how to meet those maladjustments which now threaten social chaos. Such problems as unemployment, money, banking, agricultural marketing and the control of agricultural production, adequate health and medical care, a broader system of education for all ages and international relations are forcing us to social planning, whether we will or no. To what extent our planning will result in social progress will depend upon whether we utilize the best technical ability available and whether we are willing to pay the price involved in our own education so that we may give intelligent support to the plans which we will be called upon to approve.

There is no magical formula which will ensure social progress. The old adage, "If wishes were horses, all men would ride," is still true. Our wishes may be worthy ones, but we must have the horses. We must implement our desires, by making the same use of social science for social planning as we have used the engineer and the chemist in subduing a continent and creating modern industries. The age of pioneering is not past and there is more need than ever for a new type of individualism and personal initiative devoted to the common welfare. To-day's pioneering is in the field of social discovery and social planning, which will be as difficult and will require as much moral fortitude and heroism as was ever shown in conquering the primeval wilderness. Planning for social progress offers a challenge to our keenest intelligence, to our belief in human integrity and to our true patriotism. That the challenge will be met is indicated by the response which the American people are giving to competent leadership in the attempt to secure social progress through planning, through intelligence and good will rather than through the domination of power.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE ASTRONOMY OF NAVIGATION

By Dr. LORING B. ANDREWS

EXECUTIVE SECRETARY, HARVARD OBSERVATORY

FOR those of you who are located in the interiors of the continents of the world and whose experience on the waters of the earth has been limited to boating on small lakes, rivers, ponds, and the like, reliance upon celestial objects for a knowledge of your whereabouts has hardly been necessary. Familiar landmarks on the shore or wooded islets or partially submerged rocks are sufficient keys to the position of your craft. Those of you who sail the oceans of the world, with day after day on the open sea without sight of land, nothing but water beneath and sky above your vessel, rely usually upon the wisdom of the ship's officers to guide you safely from one port to the next. To a seafaring man, however, a constant knowledge of the vessel's whereabouts is of prime importance that he may reach his destination with promptness and certainty.

Once the shoreline drops below the horizon and the vessel's course is set for a destination, distant by many watery miles, the determination of the location of the vessel becomes an astronomical problem. One square mile of water differs from any other square mile of water only in minor characteristics such as temperature, apparent color, the presence of drifting weed or in the smoothness or roughness of the surface. Such criteria are, however, hardly conclusive evidence of the location of any particular square mile, for similar appearances are to be found in endless repetition over the water-covered surface of our planet.

But whereas two observers, one, say, on a vessel ploughing the North Atlantic steamship lanes, and the other bound south from Manila to Australia, might find but little in the appearance of the ocean waters to furnish a clue to their location, the appearance of the sky at the same instant for the two observers will not be the same. At any given instant the appearance of the sky from any point on the earth's surface is completely characteristic for that place; in one locality, the sun may be rising, in another setting, in a third, it may be night and the stars be visible; perhaps in one location it is the stars in Taurus which are rising, in another they may be setting, in a third they are overhead. If one then possessed a book of drawings that gave the appearance of the sky under all possible variations of time, day and place, one might find that drawing similar to the observed appearance of the sky for the given instant of the given day, and say that he was located in the latitude and longitude for which the drawing had been made. Quite obviously such a book must remain only a dream, yet the actual way in which the navigator determines the location of his ship is almost exactly analogous. The practical navigator finds that the simultaneous observation of the compass bearings of any two celestial objects, two stars, for example, and the measurement

of the distances they appear to be above the horizon are sufficient to indicate completely the appearance of the remainder of the sky and to determine the latitude and longitude of the ship at the moment the observations were made. Let us trace the procedure, using a numerical example.

Imagine that you are a passenger on a vessel steaming along the mid-Atlantic beneath a starlit October sky. At exactly 11 o'clock by your watch, which perchance is keeping correct Eastern Standard Time to the very second, you observe the bright star Capella to bear ENE and to be 49° above the horizon, and at the same time observe that blue-white Vega bears NW by W and is 19° above the horizon.

If, at the instant, instead of being on shipboard in mid-Atlantic you had been located in the Italian Alps near Mount Cervin, the star Capella would have appeared directly over your head, that is, in your zenith. You would then have been standing at the so-called sub-stellar point for Capella. If, for the nonce, the earth would cease its rotation and time in consequence cease to pass, as you proceeded away from this point in the Alps along the curved surface of the earth, Capella would appear gradually to sink toward your changing horizon. It may be easily shown that for every sixty nautical or sixty-nine land miles you traveled, Capella would drop 1°, until, having traveled a quarter way round the earth, you would find the star on your horizon. You have the choice of withdrawing from the sub-stellar point in any one of an infinite variety of directions, and, since the earth is, to all intents, a sphere, the distance you would find it necessary to withdraw to produce any desired result would in every case be the same. The locus of points from which at 11 P. M. the observed altitude of Capella would be the same is therefore a circle with its center at the sub-stellar point. This circle is called for self-evident reasons a circle of equal altitudes. From your ship in mid-Atlantic the altitude of Capella was observed to be 49°. To cause the altitude of Capella to reach this figure, you would find it necessary to withdraw from the sub-stellar point a distance of 2,560 nautical miles. On a large globe of the world then you might describe this circle and say that somewhere on the circle the ship must be. Of course you were not completely lost before you made your observation. You can easily restrict your choice of position on the circle to a small arc of it somewhere in mid-Atlantic and therefore draw only a small portion of the whole circle. This small portion is called a line of position for your vessel, an arc of a circle upon which your ship must lie.

Your one observation is obviously not conclusive. It does not tell you at which point of the line of position the vessel is located. However, at 11 P. M. you also observed from your ship that Vega had an altitude of 19°. Your ship must also lie on a second circle with center at the sub-stellar point for Vega and with an appropriate radius derived from the observed altitude, in this case 4,260 miles. It may be shown that at this instant the sub-stellar point for Vega was located approximately 1,300 miles due west from San Francisco. Again a small arc of this circle will suffice, an arc in the region in which the vessel is sailing, a second line of position. It should hardly be necessary to suggest that the two lines of position, the one from Capella, the second from Vega, will intersect, thereby designating the vessel's location and solving your problem. Such is the essential background to the method of determining by astronomical observation the position of a vessel at sea.

In actual practise the navigator of a

vessel represents these arcs by straight lines. This is a valid procedure, since the circles are so large that the small arcs used deviate but infinitesimally from straightness. Mathematically, the navigator computes the latitude and longitude of one point which is in the neighborhood of the ship's approximate location and is at the same time on the circle of equal altitudes. He also derives by mathematics the bearing of the object observed, for the orientation of the line of position through this computed point is always at right angles to this direction. The geographical location of the sub-stellar point is not necessary to the practical solution of the problem. Frequently a third line of position resulting from the observation of a third body is drawn to serve as a check against possible errors of observation.

As they appear to the eye the stars are most readily pictured for such problems as these, as located on the inner surface of a sphere, the celestial sphere, concentric with the sphere of the earth, and with an infinite radius. The exact locations of the stars, the planets, the sun and moon and other celestial bodies upon this inner surface has involved the astronomer's attention from earliest time and their relative locations are carefully and accurately recorded in nautical almanacs. The celestial sphere apparently rotates once every twenty-four hours about an axis coincident with a line passing through the north and south poles of the earth. The exact time of observation serves to fix the particular orientation of the celestial sphere upon its axis at the moment, and thereby to fix the geographical location of the sub-stellar points. Since the location of the circles of equal altitudes at any instant is in turn dependent upon the location of these sub-stellar points, the exact time of observation is clearly essential to the solution of the problem.

For the purpose of determining this time accurately all ships carry at least one accurate timepiece, called a chronometer, which is an exceedingly carefully constructed clock mounted in gimbals so that it will maintain a constant horizontal position regardless of the roll and pitch of the vessel. It is commonly found that a change in the orientation of a timekeeper changes the rate at which it gains or loses. Due to its stability the rate of gain or loss of a chronometer is usually very constant, so that its error at any time may be computed from any previously known error. In these days of radio, however, the radio time signals make the need for such an excellent timekeeper somewhat less important, for the error of a less accurate timepiece may be determined many times during the day. It is interesting to note that the source of the correct time which is broadcast is astronomical, for upon direct observations of the stars from an observatory with known geographical location is based our knowledge of time.

Those of you who are familiar with the practise of navigation at sea realize that not all observations for position are made at night. The sun furnishes by day a very convenient object, more easily observed than a star. Any one observation of the sun provides of course but a single line of position even as an observation of a single star provides but a single line. One observation of the sun is, therefore, not conclusive of the vessel's position. It is common practise to observe the sun, firstly, if possible, when it is due east, secondly, when it is due south and, thirdly, when it is due west. A suitable combination of the lines of position derived from these three observations separated in time, two of them running north-south and the third east-west, will give both the latitude and the longitude of the ves-

sel at any instant during the daylight hours.

Of course a ship at sea is no more bountifully provided with clear days and nights than is the average point on land and frequently many days pass without a view of celestial objects. The navigator's problem then is hardly astronomical. It involves rather a strict attention to the courses which the vessel sails and to the distances run. Knowing the point of departure of the ship subsequent positions are found in exactly the same way that you would find a street in a city upon being told that it was three blocks north and two blocks east from your point of inquiry. It is a process known as dead reckoning and is always used to fill in the gaps between positions which are determined from celestial observations.

Should you then ever travel the oceans of the world for the first time or in repetition of many an earlier ocean voyage, look aloft at the sun in an azure sky and at the star-studded vault of night and realize that these heavenly bodies are your friends and guides. Remember that on the bridge of your stout ship are the officers who know the ways of observing these objects and computing the vessel's whereabouts and where over the horizon lies the next port of call. Remember that in the observatories of the world astronomers night by night compile the reference data and determine the correct time so necessary to the solution of the problems of navigation. Wherever you sail, remember that the vessel is headed on her course to the best knowledge of those in command, and, in every case, *un bon voyage*.

MAPPING FROM THE AIR

By Professor S. S. STEINBERG

HEAD OF THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF MARYLAND

WHILE it has always been man's ambition to view the world from the air as does the eagle, the modern engineer has found in human flight the opportunity to survey and map large areas of the earth's surface at great savings in time and cost. The value of pictures from the air was first appreciated and investigated by European engineers in the latter part of the nineteenth century. Early experiments were made by using kites and balloons. The introduction of the dirigible stimulated these attempts, and finally the development of the airplane made apparent the great advantage of its use as an aid to surveying and mapping. This advancement in engineering grew out of the world war when it was extensively used for military purposes. It has been estimated that during the last years of the war 80 per cent. of the information about the enemy was obtained by aerial photography. Since the war, aerial surveying has been used as an aid to the map-maker in supplying certain kinds of detail much more faithfully than a surveyor could sketch them even by covering the terrain very closely.

The inherent characteristic of an air map is accuracy. Combined with the vivid and complete detail of the ordinary photograph is the record of true relations among the features on the ground. Houses, cultivated fields, fence lines and wooded areas are all shown in their proper proportion. An air map is a permanent and complete record, as the camera's eye misses nothing.

An aerial photograph is not a map, but a perspective view in which direc-

tions and distances may be somewhat distorted. A photograph of absolutely level ground taken with the axis of the camera truly vertical approaches a map in accuracy. If there is any appreciable relief in the ground or appreciable tilt in the camera, the images on the photographs are displaced from their true positions. However, the photographs are still usable and by employing certain graphic and instrumental methods map construction can be expedited tremendously.

Successful flying over an area for the purpose of mapping calls for skill on the part of the pilot and a thorough knowledge of the use and care of the camera on the part of the photographer, with fine teamwork between the two. Experienced airplane pilots consider air mapping the most difficult kind of flying. Traveling at a speed of 100 or more miles an hour in the thin cold air at high altitudes, with eyes concentrated on the instrument panel to maintain a straight course, with wings level, is a constant strain on the pilot.

Most of the flying is done at altitudes as high as two or three miles above the ground. Below 7,000 to 8,000 feet the air currents are full of gusts and bumps which render the results unsatisfactory, while at altitudes as low as 3,000 to 4,000 feet accurate air mapping is quite impossible.

As the plane ascends, the temperature of the air drops rapidly, on the average about one degree for each 300 feet of ascent. At altitudes of 15,000 to 20,000 feet, at which most of the flying for mapping is done, the air is piercingly cold even in midsummer, being 50 to 60 degrees lower than on the ground. For flying above 21,000 feet oxygen tanks are necessary for pilot and photographer. Aerial photographs have been taken from altitudes as high as seven miles.

With a given mapping project in view, a guide map is prepared with flight lines on it to enable the pilot of the plane to cover completely the area to be mapped. By comparing the objects on the guide map with those on the ground the pilot is able to fly in straight parallel courses back and forth. Accurate aerial surveying requires an airplane that is reliable, sturdy and powerful, one that is capable of sustained flight at all altitudes, that can rise and descend in small fields, that can fly true to line and that is economical of fuel. The altitude at which the plane should fly in order that the photographs may be made at a predetermined scale is dependent on the general elevation of the country and the focal length of the camera lens. Practically cloudless weather is necessary to secure good aerial mapping photographs. In most of the United States only one day in seven can, on the average, be depended upon for such work.

While the first aerial photographs were taken with a single lens camera, the U. S. Geological Survey, during the world war, designed and constructed in cooperation with the National Research Council the first experimental three-lens camera which permitted taking vertical photographs from the air, each exposure of which covered a wide area along the line of flight. The next development was a four-lens camera by army engineers, which was followed by a five-lens camera, and the latter is now used for standard aerial mapping in the army. The five-lens camera is constructed with the axis of the central lens pointing vertically downward with the four other lenses grouped symmetrically about the central lens and at constant angles from the axis of that lens. After the oblique photographs taken by the four side lenses are transformed to horizontal planes and assembled with the central photograph, the result is a composite pic-

ture shaped like a maltese cross. This camera is designed exclusively for small-scale mapping and permits covering an extremely large area in a single exposure. For example, a flight at 18,000 feet altitude results in covering a strip 18 miles wide. On a recent project in Maine, 3,500 square miles were covered in three hours by 160 exposures.

The ultimate development of the multiple lens camera idea seems to lie in a nine-lens camera which will fill the gores between the four oblique lenses and present a complete picture covering an entire area at a single exposure. A German nine-lens camera has already been developed and is designed largely for exploration work. It can cover an area of 200 square miles at a single exposure from an altitude of 16,000 feet. A nine-lens camera has been developed in the United States, but expense of manufacture has postponed its production.

The aerial mapping camera is of rigid all-metal construction and points straight downward through a special hole in the bottom of the plane. It is so suspended in a gimbal mount as to permit the optical axis being kept vertical, regardless of the oscillations of the airplane. It is not a motion-picture camera, but takes still pictures 7 by 9 inches in size, at any desired time interval. It is operated either automatically or by hand. Generally, successive exposures are made from 10 to 15 seconds apart. The film is 75 feet long, sufficient for making 110 exposures. The film holder may be quickly removed and replaced with another magazine, thus making it possible to secure a very large number of exposures in the course of one flight. The shutter is capable of opening and closing in the 150th part of a second. With its various accessories, the camera weighs about 50 pounds.

The photographer times the successive exposures so that they overlap each other like shingles by about 60 per cent. in the direction of flight and about 50 per cent. sidewise in successive flights. The overlap makes it possible to use only the central portion of each photograph, which alone is in true vertical projection. The overlap, moreover, allows stereoscopic study of the terrain.

One of the most interesting and most important developments in mapping from the air is the stereoscopic use of aerial photography. The interpretation of aerial photographs is much easier when overlapping prints are examined stereoscopically. The instrument used for this purpose, though much larger and more complicated, is based upon the same principle as the once familiar parlor stereoscope. This instrument has the peculiar property of causing the photographic image to be seen in a third dimension, namely, that of relief, with the hills standing out above the valleys, and the houses, trees and other objects strikingly visible in three dimensions. The practical advantage of stereoscopic vision to the engineer is that, with suitable mechanical devices, he is able to draw from the photographs contour lines, which are lines of equal elevation and are of great value in the study of any proposed engineering project. In making topographic maps from aerial photographs of Zion and Bryce Canyon National Parks in Utah, the U. S. Geological Survey used a stereoscopic instrument, with a resulting saving of about 50 per cent. in time and 30 per cent. in cost.

Aerial photographs have been utilized for many purposes. They have been found of value in city planning and zoning, in studying highway traffic problems, for irrigation and water supply projects, for river and harbor development, flood control, timber estimates, geological study and tax assessment purposes. Middletown, Connecticut, was the first municipality to be revalued by an

aerial survey. As a result, nearly 1,900 buildings were discovered which had previously escaped taxation.

Aerial mapping is preeminently useful in surveying difficult and inaccessible country. Low-lying swamps and coastal areas can be mapped adequately by no other method. The U. S. Coast and Geodetic Survey has used aerial surveying extensively, in conjunction with its ground control, in mapping the complicated coast lines of Florida, Louisiana and the Pacific region.

Air mapping is employed by the United States Army wherever it is practicable. It is now engaged in mapping from the air part of the Olympic peninsula in the state of Washington, a region of heavy rainfall, dense forests and rugged topography. The largest single aerial mapping job done by the army during the last few years was that of mapping for the purpose of flood control practically the entire alluvial valley of the Mississippi River from Cairo, Illinois, to the mouth, an area of more than 50,000 square miles. In addition to the government agencies mentioned, there are several commercial firms that are splendidly equipped and are doing excellent work in the field of air mapping.

The mapping of the United States has gone forward since the early days of discovery and settlement, and particularly as a result of the efforts of such government agencies as the Coast and Geodetic Survey, during the more than 100 years of its existence, and the Geological Survey during the past 45 years. Yet to-day only 25 per cent. of the area of the country is adequately mapped, and more than half of the United States has never been mapped, even in the crudest way. At the present rate of progress it will take almost a century to complete the basic map of the United States. While mapping from the air will never replace ground surveying, it will serve to expedite the production of maps so urgently needed for national planning, public works and the general welfare.

WHEN THE PAST BROKE ITS SILENCE

By Dr. E. A. SPEISER

UNIVERSITY OF PENNSYLVANIA

If we were granted a leave of absence from the present for a brief vacation in the past, to what distant period would we turn for a change of historical scenery? Many have posed this question, in one form or another, and the answers recorded range over a long stretch of time. The individual choices depend entirely on what our privileged travelers may be interested in and on how much they may know about the age which they would thus favor. Havelock Ellis, *e.g.*, admits in one of his essays that the thirteenth century of the present era would have suited him admirably for such a purpose. Others have hastened to reserve vantage points in ancient Greece and Crete, Palestine and Egypt. We may feel certain that India and China have found numerous bidders and that, in fact, scarcely a spot on the globe or a moment in the progress of mankind has been neglected in this revealing intellectual pastime.

There is, however, another small portion of the ancient world which is destined, I believe, to attract an ever-increasing volume of this rather unusual tourist traffic. The region in question is Mesopotamia, and the time is

the end of the fourth millennium B.C., or just about five thousand years ago. And the reason for this long-range attraction? We have here a juncture at which we are in a position to witness an event that is unique alike in importance and in interest. For what is about to take place is man's first appearance upon the stage of history. For countless millennia—anthropologists now compute the period at more than a million years—primitive man had been advancing towards this particular goal. There had been an all but timeless era of groping. Even the comparatively recent age of what we now term prehistoric civilization was very long in fulfilling its course. But at last the apprenticeship is completed, the stage set. Modern life is ready for its debut. How did the event come off? If we time our visit judiciously we may be able to view not only the dramatic feature itself, but also some of the back-stage preparations as well as the immediate effect of the performance on the contemporary audience. In other words, how was history ushered in, what were the principal factors behind the changes involved and how was life affected by these happenings?

Excavations conducted within the past ten years have furnished the answers to these questions. Before we proceed with the account, however, it will be well to consider for a moment the essential difference between prehistoric and early historic times. Where do we draw the line and with what justification?

Prehistoric man is known to us from a vast mass of material remains. By the end of the Late Stone Age he had developed a high civilization which is reflected in his tools and vessels, his art and architecture, and in the nature and manner of his worship. Some of his finest products have never been surpassed. These notable achievements are by no means sporadic or accidental. They are the direct outcome of a long and continuous advance in which numerous groups played vital rôles. The steady development of late prehistoric civilization can now be followed through some twenty successive stages represented by as many occupations or strata superimposed upon one another. Such uninterrupted sequences of settlements have been found, for instance, in Erech in the south and Tepe Gawra[1] in the north of Mesopotamia, to mention only two notable instances. It may be added that parallel sequences, though not nearly so complete, have been brought to light in Persia, Asia Minor, Syria, Palestine and Egypt. And yet, despite this impressive succession of archeological generations, the people of that age remain shadowy and anonymous. We may admire their work and appreciate their talents, but we are doomed to remain in ignorance as regards their racial affiliations, their speech and the identity of their rulers and artists. To us they are indistinct and inarticulate; in short, they are prehistoric.

It follows that in order to be classed as historical a given period must be articulate; and to be articulate it must be literate. It should be able to convey its message to posterity not only through the medium of material remains, but also by means of written records, thus placing an effective check upon the impermanency of time. When we learn, *e.g.*, that the first independent ruler of the city of Ur was a certain Mesannipadda, that the language he spoke was Sumerian, that he made war on the people of Erech and gave costly presents to his wife, whom he mentions by name, we realize at once that quiet and anonymity have departed forever and that

[1] *Cf. The American Journal of Archaeology*, 36: 462–471, 1932.

history is upon us in full sway. It all began the moment the past had broken its silence.

Having discovered what it was that first made history, we may now assign to this event a reasonably accurate date. We have seen that the unbroken story of Mesopotamia's past begins in the Late Stone Age. From then on successive settlements in sites soon grown into tall mounds take us up step by step far into the Age of Metal. In the course of this ascent we have an ideal opportunity to study the progress of writing. The first signs, in the form of crude and obscure pictographs, are encountered after some fifteen steps or strata have been left behind. From these modest beginnings a complete system of writing is evolved within a few hundred years, and this evolution is accomplished at close to 3,000 B.C. The beginning of history proper dates, therefore, from that time.

But is the difference between prehistory and history merely a question of more or less successful scribbling? Was life in general much the same on both sides of that divide? Decidedly not. The contrast between the two ages that face each other across the flimsy borderline of a few decades is so sharp and distinct that nothing like it is seen again until we get down to within earshot, so to speak, of our own times. This brings us to the other vital element in our story —the coming of copper.

As we have seen, the Near East had an advanced culture centuries before that time when some unsuspecting genius presented mankind with a long memory by having hit upon the idea of writing. Your Mesopotamian or your Egyptian of the fourth millennium B.C. can hardly be mistaken for an insensitive barbarian. He built temples which arouse our envy and admiration by the symmetry and simplicity of their design. His carvings on plaques and seals were animated with an unending variety of amazingly lifelike scenes. Hard stone was transformed into graceful beads and amulets, and even the fragile ceramic fabrics showed in their decoration the delicate and imaginative touch of the artist. Such economic necessities as flint and obsidian, which were required for the manufacture of tools and implements, could apparently be had for the asking. Life appears to have been peaceful and leisurely and on the whole uneventful.

When copper first found its way into the principal centers of the ancient world, late in the prehistoric period, no one could have suspected that the first great industrial revolution would be made of just this sort of reddish stuff. To the craftsman who hammered it into shape the metal was merely a costly substitute for stone; a rarity and nothing more, incapable of disturbing the even tenor of contemporary ways.

But at length the discovery was made that when the metal had been reduced and then remelted, it could be cast so as to yield any desired shape. Unlike the rigid stone, copper became pliable and strangely responsive. In other words, some one had finally stumbled upon the basic principle of metallurgy.

The rest is a matter of history in more ways than one. The discovery opened up vast horizons, and it was not long before the established order of things was completely upset and out of date. Event followed upon event with alarming rapidity. Home industries received a powerful impetus and foreign contacts acquired a new meaning. Stone-users were no match in battle with the wielders of the new copper weapons. Possession of the metal became a stark necessity and, since the known mines were limited in number and restricted to a few locations, there was a mad scramble to control the sources of supply. Dis-

tances were disregarded in the search for new deposits. In the heat and dust of this upheaval whole nations were shifted and transplanted almost over night. When the smoke had at last cleared it was an entirely different world that faced the unknown future; a restless world, constantly on the move. And when did life assume this dynamic character? By a coincidence that may not be altogether remarkable, shortly before 3000 B.C.

This, then, is the picture restored from a few old and long-inhabited sites of Mesopotamia. You can not mistake its main outlines once you have been fortunate enough to find and excavate such a place. An excellent example of one is Tepe Gawra, near Mosul, Iraq, which I had the privilege to explore for the joint expedition of the American Schools of Oriental Research, the Dropsie College of Philadelphia and the University Museum of the University of Pennsylvania. First you are impressed by the beauty and restraint of the prehistoric civilizations. Then you reach a point where these come to an end. A few feet of earth, and you have ascended to a different world. Across that enormously significant border are the foundations of modern life; great wealth and industry and skill, and with it all a feeling that everything is somehow in a state of flux. And the ground is literally green with copper.

Thus writing and metallurgy, or literature and industry, in a somewhat incongruous alliance, combined to usher in history. The profound revolution which these factors brought about is without analogy for thousands of years. It is not until we come down to the beginning of the last century and note the changes wrought by the advent of the Steam Age that we find anything comparable in magnitude. This parallel is more complete than appears at first glance. But we must not tell the whole story, or there would be no point to the trip that we spoke about at the beginning. So if that cosmic opportunity is still open to you, and if you can tear yourselves away for a while from the excitements of the present, won't you book passage for Mesopotamia at 3000 B.C.? Or would you rather have a less stirring vacation?

INTERPRETING SCIENCE TO THE PUBLIC

By L. N. DIAMOND

JAMES MONROE HIGH SCHOOL, NEW YORK CITY

In the introduction to the collected works of Robert Boyle, the distinguished English scientist of the seventeenth century, appears the following:

> He endeavors to make all things he treats of plain, easy, and familiar. There is no deep knowledge of mathematics or algebra requisite to understand him fully. . . . What principally recommends our author and distinguishes him from the vulgar herds of chemists, naturalists, and philosophers is this humane temper, this candid, generous disposition, this wide learning; the whole seasoned with much wit and style.

And when one opens the pages of Boyle's works, one can not help being impressed with the fluent and lucid style in which his numerous discoveries are expressed. Certainly, the writings of many contemporary scientists would suffer by comparison; at least in the mind of the lay reader.

One need not seek very far for the explanation. Scientists, as contrasted with the man on the street, speak another language. The layman finds the jargon of scientific circles unintelligible; strewn with the boulders of technical formulae; abounding in steep precipices of outlandish vocabulary which lead the unwary to a dismal end. Unacquainted as he is with the quantitative techniques increasingly used in research, he shies away from the abstruse formulae which scientists use as a matter of course.

However, the point can not be sufficiently reiterated that effective adjustment to the world in which we live is conditioned by the extent of our acquaintance with its phenomena. It is as true to-day as in Huxley's time that our lives and fortunes are the stakes in a game of chess of which the world is the chessboard, the pieces are the phenomena of the universe and the rules of the game are the laws of nature. Scientists to-day are engaged in the task of creating a world vastly different from that of our grandfathers, and the necessity arises of assimilating their discoveries upon as wide a social scale as possible.

Unfortunately, experience has amply demonstrated that we can not leave the task of assimilation to the scientist. Rarely, indeed, is he equipped with the ability to translate his discoveries into the language of the street. For every investigator who has succeeded in writing effectively for the press and in carrying on creative research at the same time, there are hundreds of others who have made the discovery that science is an exacting mistress who brooks no dalliance with the newspaper. True, there have been scientists, such as the late Sir E. Ray Lankester, whose delightfully informal style is one of the glories of English journalism and whose impressive volume of discovery is one of the glories of biology. Nevertheless, this combination of the two abilities is a rare one, and in our age of specialization it appears that the interpreter, equipped with a special training and technique, is necessary as the liaison officer between the scientist and the layman. Of the crucial need for the interpreter none has written better than Glenn Frank, president of the University of Wisconsin:

> The future of America is in the hands of two men—the investigator and the interpreter. We shall never lack for the administrator, the third man needed to complete this trinity of social servants. And we have an ample supply of investigators, but there is a shortage of readable and responsible interpreters, men who can effectively play mediator between specialists and laymen. . . . A dozen fields of thought are today

congested with knowledge that the physical and social sciences have unearthed and the whole tone and temper of American life can be lifted by putting this knowledge into general circulation. But where are the interpreters with the training and willingness to think their way through this knowledge and translate it into the language of the street. I raise the recruiting trumpet for the interpreters.[1]

In recent years, there has been a steadily increasing recognition of the need for a systematic program of publicity on the part of institutions devoted to scientific research. For one thing, the depression has driven home the point that the support of these institutions depends in large measure upon the good will of the public. Now that the Croesuses who gave so generously have been compelled to tighten their purse strings, scientists have realized that the confidence of the community in their work is requisite for adequate support of their programs. Certainly the need is great. As Watson Davis writes:

The pinch of scientific research hunger is being felt, illogically and cruelly. Take the Federal Government, for instance, rightly one of the principal supporters of science. In a typical year (1932) about $40,000,000 was spent upon the wide-flung and highly profitable scientific research activities of Uncle Sam. That is little enough. It pays dividends that make the conventional 6 per cent. look insignificant; demonstrable dividends that run from 100 per cent. to 1,000 per cent. per year on the money invested being frequently obtained in scientific research. Yet Uncle Sam is spending less than $29,000,000 this fiscal year on scientific research and millions of dollars of research funds were carved off the Federal budget in the name of economy since March 4th. The same sort of story is being enacted in universities, foundation-supported laboratories and in industrial concerns.[2]

A most ambitious program for the interpretation of science is that of Science Service, located in Washington, D. C. Founded by the late E. W. Scripps in 1921, it represents such well-known organizations as the National Academy of Sciences, the National Research Council and the American Association for the Advancement of Science. A tremendous debt is owed the late Dr. Edwin E. Slosson, the first director of Science Service. He was extraordinarily successful in clothing the dry bones of science with the flesh and blood meanings of the man on the street until his unflagging enthusiasm and devotion to his work resulted in his death.

His work has been carried on most effectively by Watson Davis, the present director. Under his direction, Science Service is pioneering in new fields; phonograph records of talks by eminent scientists are offered to schools, manuscripts are edited, revised and criticized for publishers, and science news talks prepared by eminent scientists are broadcasted weekly over a nation-wide network. However, Science Service is best known for its numerous syndicated press releases which are offered to newspapers on a non-profit making basis. Examination of these releases gives one an impressive picture of the struggles of scientists on the frontiers of knowledge on every part of the globe, inasmuch as some 350 scientifically competent correspondents report to Science Service from practically every world capital.

Unfortunately, neither Science Service nor any other organization devoted to the publicizing of science seems to give much attention to the valuable mass of knowledge of the past; knowledge of crucial importance in understanding contemporary developments. In consequence the gains of knowledge of the past must remain embalmed in the pages of the text-book. However, this is the advice Dr. Slosson gave would-be interpreters of science:

Don't think that because a thing is old to you it is known to the public. Many of your readers are still living in the nineteenth century; some of them in the eighteenth. Anything new

[1] Glenn Frank, *School Science and Mathematics*, 24: 5, 459, May, 1934.

[2] Watson Davis, unpublished address delivered before the North Carolina Press Association, Chapel Hill, N. C., January 19, 1934.

to your readers is "news" to them if hung on a timely peg.[3]

Many newspapers have made vast strides in the presentation of scientifically accurate science. It is no longer necessary to tie every scientific article to a fundamental passion or to resort to witchcraft in its explanation. During the past few years there has been a welcome shortage of such hardy perennials as telepathy; cancer "cures"; whiskey as a cure for snake bites; marking of children by experiences of mother before birth; living "missing links"; perpetual motion and others too numerous to mention. Dr. Austin H. Clark, who has done invaluable work in educating newspapermen as press representative of the American Association for the Advancement of Science, is of the belief that reporters are less facetious and more accurate in reporting science. He writes:

> At all scientific meetings there are likely to be a few young reporters who drop into the press room for the purpose of picking up a story. Having only the vaguest ideas about science, they are at a loss to understand what the meeting is all about. But they must produce the necessary copy. So they take refuge in ridiculing or distorting the proceedings. Aggravating as this is to the victims, any attempts to exclude such reporters, or to have them reprimanded, would only make matters worse. The only way to achieve results in press relations work is to show appreciation of the good work done, and ignore the bad. It is a pleasure and a source of the greatest satisfaction to be able to say that difficulties from this source, which were numerous and trying to the patience a decade ago, have now almost entirely disappeared. Even the youngest, greenest and cubbiest reporter now takes science seriously.[4]

While the press and other organs of publicity are disposed to cooperate with agencies seeking to interpret science, the total of scientific news appears to be amazingly low. The writer clipped and measured scientific articles appearing in four newspapers having the widest circulation in Washington, D. C., and two newspapers in New York City from May 12 to August 28, 1934. Excluding the Sunday editions, an average of only 2.4 articles pertaining directly to science with a total length of 13.6 inches appeared in each paper daily. This small figure requires further analysis as to the extent of each science contributing thereto over a much longer period.

Research workers, it must be admitted, have barely tapped this rich field of scientific interpretation in the press. Charles W. Finley and Otis W. Caldwell made a promising start in their study, "Biology in the Public Press."[5] These two investigators carefully examined the issues of 17 prominent newspapers for the months of June and November, 1921, in an effort to ascertain the type and amount of scientific materials appearing in them. However, their work needs to be repeated so as to bring it up to date. Moreover, a long-time investigation—over a ten-year period, let us say—would give us a more adequate basis upon which to modify our scientific curriculi on all educational levels. As Finley and Caldwell suggest, since these types of knowledge are going to the public in such large quantities all over the country, they surely reflect genuine needs and interests which should be taken into consideration in constructing courses of study.

The radio is a further untapped field of investigation. However, in comparison with the press, it fairly bristles with difficulties. For example, most stations keep incomplete records of educational broadcasts; in all too few instances are copies of scientific talks kept in their files. Some idea of what has been presented can be obtained from bulletins

[3] Edwin E. Slosson, unpublished mimeographed instructions for correspondents of Science Service.

[4] Austin H. Clark, "Science and the Newspapers." Unpublished.

[5] Chas. W. Finley and O. W. Caldwell, "Biology in the Public Press," Lincoln School of Teachers College, 1923.

announcing forthcoming programs which stations send to newspapers if one is willing to make a rough guess as to the content of a talk with only a brief title as a guide. And, as Dr. Cline M. Koon, specialist in education by radio of the United States Office of Education, informed the writer, it is not a rare occurrence for broadcasters to change their minds and speak upon a different topic than that announced in the newspaper.

There have been a good many interesting developments in interpreting science to the public by means of the radio which deserve wide publicity and dissemination. The Columbia Broadcasting System, in its School of the Air, stresses the value of informal discussion between the expert and the layman, as contrasted with a monologue by the former. Actuality broadcasts are being used on an increasing scale. By these are meant the broadcasting of important events at the time of their occurrence. An example is the recent talk by William Beebe from his bathysphere off the coast of the Bermudas. Beebe was an exceptionally fine broadcaster and those listening felt in a most tangible fashion the confining walls of the diving bell as it was lowered from the surface water a half mile.

But here again, he who would interpret science by means of the radio has very little to guide him. Research is needed as to the interests of the radio public as well as their scientific background. Scientists need instruction as to the proper technique of writing and delivering a talk. Broadcasters often point out that the scholar is often an absolute failure on the air because of his inability to translate the language of science into the language of the street, the market-place and the home. Not enough effort is made to motivate talks in terms of fundamental human experiences and emotions. Nevertheless, scientists are learning rapidly. Here is what Austin H. Clark, curator of echinodermata in the United States National Museum, writes:

> In a radio talk the opening paragraph must include something sure to interest the listener so much that he or she will continue to listen. For instance, suppose that I am giving a talk on "The Cow-bird" and I begin, "Our cow-bird, like most cuckoos, the honey-guides of Africa, some weaver-finches, some hang-nests, the rice-grackle, and a South American duck, and according to recent information one of the paradise-birds, lays its eggs in the nests of other birds which hatch these eggs and raise the young," the number of listeners will be reduced to the vanishing point long before I have reached the end of the sentence.
>
> In the first place, the title—"The Cow-bird"—is too grimly prosaic and means nothing to most people. In the second place, the long string of wholly unfamiliar names of foreign birds would cause the mind to skid unpleasantly and finally to run off the road entirely.
>
> But if I change the title of the talk to "Abandoned Bird Babies" and begin "Those unfeeling mothers who leave their little babies upon the door-steps of prosperous people's houses have their counterparts among the birds," etc., I shall be able to follow it up with a very considerable amount of information.[6]

There is an especially pressing need in these times for responsible interpreters who can make the public critical of the pseudo-science that raucously issues from the radio and other media of publicity. Charlatans, using science solely as a catch-word to victimize the consumer, utilize the vocabulary of laboratory to sell their products. Certainly, in these times of depression, the necessity for truthful interpretation is especially urgent. To-day, magazines that have done much to improve the quality of national advertising have begun to stretch a point or two to admit advertising of products whose worth is questionable. As Rexford G. Tugwell, Assistant Secretary of Agriculture, writes:

> Believing some of the advertising they hear by radio and read in public newspapers, people to-day are using dangerous fat-reducers and are

[6] Austin H. Clark, THE SCIENTIFIC MONTHLY, 35: 352–353, October, 1932.

thereby impairing their health; they are using depilatories with dangerous drugs and are being sent to hospitals; they are using "safe" hair dyes only to get lead poisoning for their trouble and money; they are taking radium water and are breathing their last; they are trying to cure colitis with a common laxative sold at a fancy price; they are trying to treat stomach ulcers with worthless nostrums and if, in despite of the nostrum they get well, they sit down and write testimonials for the manufacturers.[7]

The motion pictures can not be ignored in a study of the interpretation of science. Certainly such films as "Arrowsmith" or "Bring 'Em Back Alive" are remarkable in their accurate delineation of scientific techniques. News reels have also done splendid work in this connection; witness, for example, the splendid work of the cameramen in filming the casting of the 200-inch mirror for the world's largest telescope at the Corning Glass Works.

Museums, also, have done wonders in interpreting science to the public. Among the many promising innovations of museums is the nature trail of the American Museum of Natural History at Bear Mountain, New York. Here, scientists have transformed fern-filled glades, swamps and often fields into an open-air school where the students—mostly young men and women of 18 to 25 from crowded New York City—are taught, not by the stuffed, glassy-eyed effigies of the museum shelf, but by the living, refreshing creatures of the open.

The coal-mine completed recently at the Chicago Museum of Science and Industry is almost breath-taking in its reality. But one thing was missing when the mine was opened to the public and scientists rectified that when they gave the mine a correct "earthy" smell by means of chemicals.

The Museum of Science and Industry, recently opened in New York City, is one which has recognized the fact that moving things attract attention. And so one finds gadgets everywhere which whirl or whizz or boom upon pressing a button. There, science is no cold abstraction to be approached with reverent awe. Eager-eyed youngsters swarm into the model airplane and manipulate the "joy-stick," or press a button and watch a model of the new stream-lined train racing a locomotive of the vintage of 1825. Visitors are scrutinized by keen-eyed investigators, and their paths from one exhibit to another are charted in an effort to determine the "eye-appeal" of the exhibits. The tempo of this dynamic museum is prestissimo and the results of an investigation of its successful practises which the Carnegie Foundation is undertaking may do much to vitalize current museum practises.

Zoos, also, are beginning to see the light! The Zoological Park at Washington, D. C., under the able direction of Dr. Mann, has done admirable work in labelling the exhibits in the new reptile house so that they actually say something of interest to the layman. An exhibit which has attracted much attention is that of famous birds of poetry. These include the nightingale, skylark, chaffinch and the old-world robin redbreast. Would that some botanical garden might take the hint and have an exhibition of famous flowers of literature. Surely it would not be very difficult to secure specimens of a "red, red rose" or a "flower in the crannied wall"!

A most important phase of interpretation is that of departments of science connected with educational institutions such as high school and university. Up to now the bulk of publicity in the press has been secured by our higher institutions of learning. R. E. Garlin, analyzing a total of 15,047 column inches of educational news in Texas newspapers, discovered that 7,776 column inches, or more than 50 per cent., was devoted to the college; 1,395 column inches, or 19

[7] R. G. Tugwell, "Advertising and the New Food and Drugs Bill," Mimeographed News Release, Department of Agriculture, Pure Food and Drug Administration, September 16, 1934.

per cent., was devoted to the high school; 575 column inches, or 8 per cent., was devoted to the elementary school and 1.7 per cent. to the kindergarten.[8]

In all these schools, there is to-day an especial need for a relationship between the school and its patrons based upon mutual understanding of each other's needs. Interpretation is essential in the task of creating an informed public opinion favorable to the support of any legitimate educational function. We must learn to deal more realistically with those forces in society which, in the name of a false economy, are throttling all forward-looking innovations in science teaching. A twofold task lies before us; first, of visualizing a finer and more authentic picture of the rôle of science in our civilization and, second, of convincing the patrons of the public school and university through an intelligent and vigorous campaign in the press and radio that only by permitting us to fulfil that vision in our teaching can we help discharge the age-old obligation which the older generation owes the younger. Needless to say, it is the first task which is the more difficult, since it is part of the American tradition for citizens to have faith and confidence in the work of their teachers. Nevertheless, we must be prepared to justify our work in the press and other media of publicity so that the public will listen to us in the face of vociferous demands for penny-pinching economy on the part of a powerful and hostile minority.

LETTERS OF ALFRED RUSSEL WALLACE TO LESTER F. WARD

By Dr. BERNHARD J. STERN
DEPARTMENT OF SOCIAL SCIENCE, COLUMBIA UNIVERSITY

In his autobiography Alfred Russel Wallace, codiscoverer with Darwin of the theory of evolution, speaks of the intimacy that developed during his tour of the United States between him and Lester F. Ward, dean of American sociologists, at that time serving as government paleobotanist in Washington. In the following paragraph he reveals their divergent views:

> As soon as the earliest flowers appeared he [Ward] took me on Sunday walks in the wild country round Washington our first being on February 13 [1887], through the stretches of virgin forest called Woodley Park, now, I believe, a botanical and zoological reserve, where many interesting plants were gathered to send home. . . . During these excursions we had many long talks and discussions while taking our lunch. At that time I was not a convinced Socialist, and in that respect Lester Ward was in advance of me, though he could not quite convince me. He was also an absolute agnostic or monist, and around this question our discussions most frequently turned. But as I had a basis of spiritualistic experiences of which he was totally ignorant, we looked at the subject from different points of view. . . .[1]

Wallace had for many years been interested in land nationalization, but he was influenced by the individualistic teachings of Mill and Spencer, and, as he put it, "the loudly proclaimed dogma that without the constant spur of individual competition men would inevitably become idle and fall back into universal poverty." Later, in 1889, after reading Bellamy's "Looking Backward," he publicly declared himself a socialist, which he defined as "the volun-

[8] R. E. Garlin, University of Texas Bulletin, No. 3044, p. 19, November 22, 1930.

[1] Alfred Russel Wallace, "My Life: A Record of Events and Opinions," 2 vols. Vol. II, pp. 117–18. New York, 1905.

Photo from "My Life" (Dodd Mead, 1905)

ALFRED RUSSEL WALLACE

A PHOTOGRAPH TAKEN IN 1878 WHEN HE WAS FIFTY-FIVE YEARS OLD.

tary organization of labour for the good of all." From that time forward he wrote trenchant criticisms of the functioning of capitalism, of which "Social Environment and Moral Progress" (London, 1913) is the most effective. Ward remained more academic in his advocacy of equality of opportunity for the masses of mankind; he preferred not to call himself a socialist but coined the term socioeracy to designate his ideal of eliminating inequalities and conferring social and economic benefits scientifically in strict proportion to merit within the framework of capitalism.

Wallace's persistent defense of spiritualism, which developed from his youthful interest in mesmerism, formed the basis also of his chief difference with Darwin over the application of theory of evolution to man, for Wallace insisted on a spiritualistic explanation of man's conscious activity. Ward, on the other hand, was outspoken in his agnosticism; in his youth he edited and wrote most of the copy for a magazine called the *Iconoclast*. He refused to curtail or modify his criticism of religion in "Dynamic Sociology" (2 vols., New York, 1883), although pressure was put upon him to do so by the publisher and by such sociologists as Albion W. Small.

In their scientific work Wallace and Ward were closely associated. In his discussion of the geological evidence of evolution in "Darwinism" (London,

LESTER F. WARD

A PHOTOGRAPH TAKEN IN 1886 WHEN HE WAS FORTY-FIVE YEARS OF AGE.

1889) Wallace used Ward's studies of the nervation of fossil leaves to show the progressive development of the vegetation of the earth.

New evidence of the friendly relationship between the two men and interesting sidelights on Wallace's views are found in the hitherto unpublished letters from Wallace to Ward discovered among the latter's manuscripts in the library of Brown University.[2]

Godalming, England, *September 25, 1887*

The receipt with other books &c. of your very fine & interesting "Flora of the Laramie Group" [U. S. Geological Survey, *Sixth Annual Report*—Washington 1887—pp. 399–557]—reminds me that I must write to you, not only to thank you for it, but also to let you know that I have reached home & to give you a short résumé of my tour after leaving Washington.

I staid a week at Cincinnati & saw there the spring flora pretty well developed in some of the bits of forest near the City; and also visited several of the Ohio mounds. At Sioux City, Iowa, I met Miss Bandusia Wakefield, a fine botanical artist & amateur botanist. At Lawrence, Kansas, I saw their (the University's) fine collection of Cretaceous Plants from the Sandstone nodules containing some very remarkable forms. At Manhattan, Kansas, Prof. Popenhoe took me on an excursion & showed me a good deal of the interesting Prairie flora which on some of the rocky hills was very rich and peculiar, and I saw more of it at Salina, Kan., where I staid a week. In California (end of May) I was too late for the beautiful spring

[2] Research by the editor on these manuscripts was made possible by a grant from the Social Science Research Council.

flowers, though at the Yosemite & "Bigbees" I saw some of the forest flora—the coniferous forests of the Sierra being grand beyond description; but on my return in July, I staid a week on the summit of Sierra Nevada & found the sub-alpine flora in perfection and very beautiful. I next staid a week in the Colorado Rockies, in the vicinity of Gray's Peak, which I ascended on foot, where I was enchanted with the glorious alpine vegetation above the timberline, 11,000–14,000 feet. I sent home parcels of plants every day, and am glad to find that a large portion of them have arrived safe. Should you ever go to that neighborhood let me recommend you to go up a valley called "Grizzly Gulch" which is far more "flowery" than the usual trail to Gray's Peak. I left this spot with regret but I had to give a lecture at the Ag. College of Michigan, near Lansing in the end of July. There Professors Beal and Bailey kindly showed me the native vegetation in some tracts of virgin forest & bog, full of Saracenias & Habenaria ciliaris, & a great number of ferns, some of which I sent home. Finding the heat very great & the country too much dried up to be interesting to me, I spent a week with the *Allens* at Kingston, Can., & then sailed from Montreal the 10th August. During all my journeys I was very well in health except that I suffered from inflamed eyes which has become almost chronic so that I cannot work or read at night. If you have made your excursion to the Yellowstone, I suppose you will have returned by this time, and if you should have brought any *seeds* of showy flowers I sould be glad of a few. There are also a few Washington plants I should like. A fine pea—was it *Lathyrus venosus* or *Clitoria mariana* you said you could send me seeds of? I should also like some *roots* of *Viola pedata* var. *bicolor*, *Silene pennsylvanica*, *Orchis spectabilis*, & *Cypripedium acaule*. These will come well if the *roots* are tied up in damp moss, the *leaves* if any in *dry* moss, & the whole packed up in a roll in *oiled paper* or *tea-lead* with dry moss. The limit of weight is now 8¾ oz. so boxes are too heavy. Prof. Beal has sent me some plants in oiled paper which have come well.

Hoping you are quite well, and with kind remembrances to Mrs. Ward, and to all my Washington friends, Believe me,

Godalming, England, *December 24, 1887*

Thank you very much for sending me a copy of your valuable work on *Dynamic Sociology*. I have spoken of it to several friends here & have lent it to one of the masters of Charterhouse School, who is much pleased with many parts of it. Your excellent account of the Philosophy of *H. Spencer* & of *Comte* is greatly admired.

I am much pleased that Mrs. Ward should have read my "Inland Life" & been interested in it. I think she would find my "*Tropical Nature*" more generally interesting.

I should have much liked to have seen "High Island" in May & June but the fates forbade. Your spring is so dreadfully long coming! We have had no snow yet & very little frost, & my garden is full of young plants coming up ready for spring, *Narcissi*, *Snowdrops*, *Anemones*, *White lilies*, &c. while two or three species of *Helleborus*, which we call Christmas roses, are in flower. Thus the interest in our gardens never ceases, & every month in the year can afford some few out-of-door flowers. In this respect only California & Florida can equal us. Hoping to receive the promised seeds & plants next summer,

Parkstone, Dorset, *November 21, 1893*

Many thanks for sending me your new book—*The Psychic Factors of Civilization*. I have read the *third part* through, carefully, & think your exposition of the scientific character of *Socialism* as opposed to Herbert Spencer's *Individualism* exceedingly forcible, and calculated to do much good. I have also looked through & read a good deal of the *first* & *second* parts, which however being so purely psychological does not interest me so much. Chapter XVII on *Social Friction* is however an exception, & seems rather out of place, & would come better in the 3rd part. If these were embodied together, with a good deal more of concrete illustration, it would form an excellent work on the Scientific Basis of Socialism which would have great value as a weapon against the individualist school, and would enlighten many who are now blinded by the prestige of Spencer & the Political Economists. The greater part of your book is so purely *philosophical* and it is so difficult to see the bearing of several of the chapters on Social reform, that I fear it will not reach beyond students of philosophy & psychology, & thus have less influence than it deserves to have in shaping public opinion as to the true method of political and Social advance.

No doubt we *are* advancing on the very lines you point out as the true ones, but only empirically, and so much in the very teeth of the popular political economy that politicians only give way to it as a concession to the demands of the populace. I think I shall try to make known your doctrine in the form of a popular review article, though it will be a difficult job.

How dreadfully Herbert Spencer has fallen off in his *Justice*. Parts of it are so weak and

illogical as to be absolutely childish. You have no doubt seen H. George's severe criticism of it.

Parkstone, Dorset, *June 7, 1894*

I am glad to hear you are coming to England. I shall not be at Oxford myself as I have long given up attending the Association, but I shall hope to see you here, either before or afterwards, & shall be glad to give you a bed for a few days & accompany you to Weymouth & Portland. You will probably meet Carruthers of the Nat. Hist. Museum, who, if I mistake not, has also studied the Cycads, & no doubt they have a fine collection at South Kensington. I have no doubt Mr. Mensell-Pleydell—a good local botanist & geologist, author of the "Flora of Dorsetshire"—would accompany us to Portland & shew you the best localities for the plant-remains. At Portland there are fine specimens of trunks 20 feet long & more outside some of the houses, and I dare say there are some good private collections, & also at the Dorchester Museum.

We are here moving on rapidly towards Socialism, more so, I think, than you in America. The majority of our more intelligent workers are socialists, but of a reasonable type, who never even think of force, but of educating their fellow-workers & then carrying out their own ideas & principles by the majority they will some day have in Parliament.

Please let me know when to expect you. There are trains from Oxford here.

Parkstone, Dorset, England, *October 12, 1898*

I should have acknowledged your *Outlines of Sociology* long ago, but I was busy bringing out my own book, and with discussions & correspondence on the Vaccination question. I read most of the chapters of your book in the copies of the original papers which you were so good as to send me, but I am glad to have the connected whole, which contains I think some of the best things re Sociology you have written. Never was sound teaching on the subject more wanted, and wise legislation, if we are not to be soon plunged into a revolution. I have been reading with great interest Mr. Wyckoff's papers on the Workers in Scribners' Magazine, and I ask myself how much longer will men continue to work at their highest tension for a bare supply of necessaries and with no prospect of rest and comfort in old age? And even to get work at all, on these terms, becomes increasingly difficult. The whole miserable system—or want of system—has also been brought more vividly before me by my son's experience in America where he has now been a year and a half. He has had the best education I could give him in Electrical Engineering—3 years in College and 3 years in the workshops & at various jobs. So far, in America, he has been able to get nothing but labourer's or lineman's work at moderate wages, but the bosses always keep them at high pressure for nine hours a day, after which of course they are not fit for much but eating and sleeping. He enjoys the work greatly, being young and strong, especially as it has enabled him to see already a good deal of the country & people. He & a friend who went out with him worked their way, mainly bicycling, from Boston through the Adirondacks to Niagara, Chicago, and to Denver, and they want to go across to California if they can manage it. He is a thorough Socialist, and makes friends with most of the men he works with, but after a job, they often have weeks or months of idleness before they get another. What a terrible thing it is that under the present social system, the vast majority of workers, however steady and well educated, have, and can have, no prospect but a life of toil and an old age of poverty or worse—and this when the work actually done, if properly organized, would provide not only necessaries but comforts for all, with ample leisure and a restful old age. Surely the coming century must see the end of the existing system of cut-throat competition, and wealth-production based on the misery & starvation of the millions!

DAVID WHITE

THE PROGRESS OF SCIENCE

DAVID WHITE: AN APPRECIATION

In the death of Dr. David White at Washington, D. C., on February 7, in his 73d year, science in general and the science of geology in particular lost one of the most accomplished and distinguished of its representatives.

A graduate of Cornell with the class of 1886, thoroughly grounded in systematic botany, paleontology and general geology, he was appointed to the staff of the U. S. Geological Survey before graduation, at first to assist Professor Lester F. Ward, in charge of the survey's paleobotanic work, in preparing illustrations of plant fossils for publication.

White's field, however, soon broadened, and after a brief excursion into Cretaceous paleobotany, evidenced by a paper on some collections from Gay Head, Martha's Vineyard, he early began to specialize in the fossil plants of the Paleozoic, a field in which Leo Lesquereaux had done the preliminary work. Within a few years, White's studies of the paleobotany of the Appalachian trough led him to conclusions about the stratigraphic relations of the Pennsylvanian beds that were widely at variance with the then generally accepted views of such eminent authorities as John J. Stevenson and I. C. White. David White's conclusions, however, at first regarded as revolutionary, gradually won acceptance and were quietly adopted by the state geologists of West Virginia, Tennessee, Kentucky, Alabama and Georgia. Thus by the beginning of the century he had won recognition as the leading stratigraphic paleontologist in his field in the United States.

From this time forward White's fields of activity and his personal influence gradually extended. No geologist working on the difficult stratigraphy of the eastern coal fields was willing to announce conclusions unless they were verified by the evidence of the fossil plants as interpreted by White.

Always a thorough and critical field observer and a skilled microscopist, he managed, as a by-product of his paleobotanic work, to collect a large body of evidence on the constitution and evolution of coal. Thus he eventually became our leading authority in this field and meanwhile was laying the groundwork for his later great generalization on the limits of oil fields, known as the carbon-ratio hypothesis.

Much of Dr. White's work illustrates the truism recognized in scientific circles, but often doubted outside these circles, namely, that even the purest types of research, entered upon with no thought of their economic significance, may nevertheless prove to have very definite economic value.

The systematic study of fossil plants would scarcely be constructed as coming within the field of economic geology, yet the identification of coal beds from outcrop to outcrop, through the associated fossil plants, and the determination that favorable structures in apparently favorable rocks can not contain commercial petroleum because associated coals indicate that metamorphism has gone too far, have the greatest economic significance.

Important and diverse as were White's direct contributions to geology in the fields of paleobotany, stratigraphy, isostasy and origin and evolution of coal and oil, they were even surpassed by his indirect contributions. Always an enthusiastic and indefatigable student himself, he was a constant inspirer of others. He took the keenest delight in bringing together a promising student and a difficult problem, suggesting and counseling out of his own broad experience, helping to overcome difficulties and lending constant encouragement wholly

regardless of any drain upon his own energies. His generosity, enthusiasm and keen personal interest, backed by his encyclopedic knowledge and his example of indefatigability, were constant sources of inspiration to his associates. There was something eternally youthful about him, something that time could not affect. His view was always ahead, toward new problems awaiting solution and the men and means for their solution. His passion was to reduce constantly the unknown by adding to the known. His life was a continuous assault on the limits of our knowledge for the purpose of pushing them back. Thus he was an intellectual imperialist, engaged in constantly extending the domain of the human mind, as all real scientists must be. Nor did he ever stop growing. Many of us by middle life lay up a capital of knowledge and thereafter live upon its income, but David White's avidity for research was as keen at 70 as at 30.

Through administration also, White contributed much to geologic advance in this country. He was chief geologist of the Geological Survey from 1912–22, chairman of the Research Council for the next three years, home secretary of the National Academy of Sciences for four years and its vice-president for two years.

During the period of the world war he developed the activities of the geologic staff of the survey into those channels of greatest service in the emergency, and at all times then and later, his counsel was enlisted through board and committee services of great variety. While these activities interfered with his own personal studies, they expanded his influence in many directions and permitted his spirit and his ideals to permeate many of the fields of science.

He stands then as an investigator of the first rank. Early established as the authority on the plants of the Coal Measures he, by that accomplishment, attained as much as is within the power of most men within a lifetime. But in addition to this he has done more than any one else, on this continent at least, to reveal the complete story of the evolution of coal of all ranks and of oil. His carbon-ratio hypothesis is one of the great generalizations of the century. He touched with profit to geologic science upon the field of isostasy. He has dealt in an illuminating way with the earliest forms of life on the planet, the fossil algae of the pre-Cambrian.

In addition to his personal accomplishments he inspired and aided many along the pathway of life. Vivid, generous and self-forgetting, he was quite as keenly interested in the sound accomplishments of his younger associates as in his own. His work will go on through them.

It is gratifying to know that Dr. White received many evidences during the last dozen years of his life of the esteem in which his associates held him. Honors from universities and scientific societies here and abroad were bestowed upon him. From these no doubt he derived much quiet satisfaction, and his associates who are left have the comfort of knowing that he did not depart from us without knowing how we felt about him.

W. C. MENDENHALL,
Director
THE U. S. GEOLOGICAL SURVEY

DR. ISAIAH BOWMAN, PRESIDENT OF THE JOHNS HOPKINS UNIVERSITY

IN choosing Isaiah Bowman as its fifth president, the Johns Hopkins University turns again to the field of geography, from which its first president, Daniel Coit Gilman, was called. Between the two stand Ira Remsen (chemistry), Frank Johnson Goodnow (political science) and Joseph Sweetman Ames (physics). The delicate question of favoritism as between the sciences and the humanities is thus answered or avoided, for geography is a child of these two parents and honors them equally. The first and fifth presidents

DR. ISAIAH BOWMAN

have both been associated with Yale, where the former was professor of physical and political geography in the Sheffield Scientific School. Friends of Hopkins will hope for another parallel. The man who chose Gildersleeve and Sylvester and Martin and Rowland and Newcomb at the outset, when it was necessary to meet classes in old dwellings, knew something of men and was able to distinguish between the essentials and the incidentals of a university.

The new president's mature years have been given to teaching, to productive scholarship and exploration and to administration in almost equal measure. His teaching began in the public schools of Michigan, where he grew up. It continued in the State Normal School (now College) at Ypsilanti in association with Mark Jefferson. Again at Harvard, before his graduation in 1905, he was assistant in physiography under William Morris Davis. Those who knew Jefferson of Ypsilanti and Davis of Harvard might well expect that the future geographer should be exact in his own scholarship and properly rigorous in his requirements of others. Ten years were then spent as instructor and assistant professor at Yale. Formal teaching ended in 1915, when he became director of the American Geographical Society and editor of its publications.

The American Geographical Society was already a distinguished institution. Its library, map collection and *Bulletin* gave it rank among the leading geographic societies of the world. In 20 years these have been greatly developed. The character and the success of *The Geographical Review* (successor to the *Bulletin*) would of itself give distinction to any scientific society.

It was during his service at Yale that Bowman did his work as an explorer. He was leader of the first Yale South American Expedition in 1907 and geologist and geographer of the Yale Peruvian Expedition in 1911. His first intimate connection with the American Geographical Society was in 1913, when he headed the expedition of that body to the Central Andes. The maps and reports resulting from these expeditions greatly increased the world's knowledge of little-known regions and stimulated interest in our neighbor continent.

It required initiative, even daring, to lead the American Geographical Society into committing itself, its resources and its future prospects to a project which is, beyond comparison, the greatest single piece of work ever undertaken by a geographical society, that is, the compiling of a map of Latin America on a scale of 1:1,000,000 in conformity with the standards of the "Millionth Map of the World," sponsored by the International Geographical Congress. Work was begun fifteen years ago and is now far advanced. The total cost will be several hundred thousand dollars. A special staff was assembled for the purpose and many thousands of maps, traverses, surveys of claims and confidential documents have been subsidiary to the work. To say that Latin America is now better mapped than the United States would be ambiguous and in a sense incorrect. But to say that the *existing knowledge* of South America is vastly more available for general use than the corresponding knowledge of the United States is a safe statement.

Among the necessities of the war was that of getting ready for the peace conference. A body, undefined by law and known simply as "The Inquiry," functioned under the general supervision of Colonel House, by order of the President. After passing through several tentative forms it took final and effective form under the direction of a triumvirate consisting of Isaiah Bowman, Allyn Abbott Young, of Cornell University, and Charles Homer Haskins, of Harvard. The work of a large staff was carried on for many months at the house of the American Geographical Society, the immediate direction being largely in the hands of Dr. Bowman, who accord-

ingly became chief territorial specialist for the American Commission to Negotiate Peace and a member of various other territorial commissions during the sessions of the peace conference.

Each part of this active career has given occasion for one or more books. A lasting result of the ten years teaching at Yale was a massive volume called "Forest Physiography." It embodies the first systematic treatment of the physiography of the United States in the light of geologic and other scientific literature. Even now, after twenty-four years, it stands alone for half the area of our country. Two or three volumes followed the exploration in South America, and as many more the Peace Conference. Recent books on "The Pioneer Fringe" and "Geographical Thought in Relation to the Social Sciences" are essays in the treatment of human relations, toward which field the author has steadily advanced from his earlier studies in the physical basis of geography.

A call to the chairmanship of the National Research Council in 1933 resulted in an arrangement by which Dr. Bowman gives one half of each month to that position and the other half to his former work. The work in Washington has entailed other responsibilities, among them the vice-chairmanship of The Science Advisory Board, whose work, though but little publicized, deals with many basic governmental functions.

Honors, offices, medals and memberships in learned societies, home and foreign, have come to Dr. Bowman in abundance and are listed in published biographical sketches. Among the more recent honors was the presidency of the International Geographical Union, which met in Warsaw, Poland, in the summer of 1934.

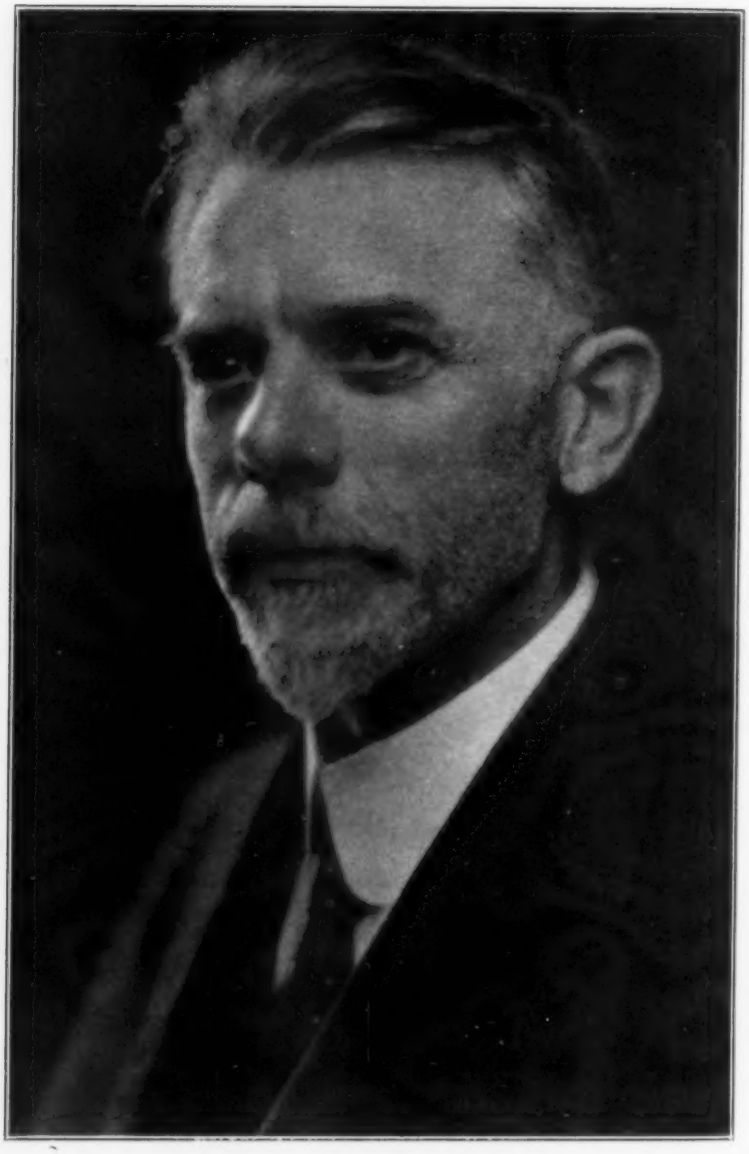
NEVIN M. FENNEMAN
Professor of Geology and Geography
UNIVERSITY OF CINCINNATI

PROFESSOR CHARLES A. KRAUS, WILLARD GIBBS MEDALIST

THE Chicago Section of the American Chemical Society has recently announced that Dr. Charles A. Kraus, professor of chemistry and director of chemical research at Brown University, has been selected as the recipient of the Willard Gibbs Medal for 1935, for outstanding work in the field of chemistry. This award was established in 1910 by William A. Converse, and each year, with the exception of 1922, has been made to a chemist for important and distinctive work in the advancement of the science. It is regarded as one of the highest honors that can be bestowed upon any chemist by American chemistry.

Dr. Kraus received the bachelor's degree in electrical engineering at the University of Kansas in 1898. While still an undergraduate he became interested in the properties of metals and liquid ammonia solutions. Interest in the latter was due to the influence of Dr. E. C. Franklin, at the time professor of chemistry at the University of Kansas. Several articles were published by these two workers before 1900 relative to the physical and chemical properties of liquid ammonia solutions.

Later Kraus found his way to the noted laboratory of A. A. Noyes at the Massachusetts Institute of Technology, and in 1908 he was awarded the Ph.D. degree for work on the properties of solutions of metals in liquid ammonia. He showed that the alkali metals are capable of forming solutions with ammonia, a non-metallic solvent, which at high concentrations behave as metals, in that they conduct electricity metallically, while at low concentrations they are salt-like or ionic in nature, in that they exhibit the electrolytic type of conductance. These studies and others of a similar nature carried out by Kraus have led to developments which are of importance in the understanding of the metallic state of matter. The actual ex-



PROFESSOR CHARLES A. KRAUS

perimental work was accompanied by many difficulties, but terminated successfully, due, for the most part, to the extraordinary manipulative skill and keen imagination of Kraus.

Many other problems involving liquid ammonia as the solvent medium have been investigated by Kraus. He has used this solvent because it offers better experimental conditions for the problems which have occupied his attention. Many of the substances he has studied are either not soluble in water or do not exist in an aqueous medium due to their extreme reactivity. For example, the alkali and alkaline earth metals, metallic compounds, such as Na_4Pb_9, Na_3Sb_7, Na_3Bi, Na_4Sn_9, etc., are not capable of

existence in water, but all are soluble in liquid ammonia with the formation of stable solutions.

The latter named substances, the metallic compounds, have received considerable attention by Kraus in his researches. He has demonstrated that the alkali metals react with many of the less electropositive elements, such as lead, tin, antimony, arsenic, bismuth, selenium, tellurium, etc., to form metallic compounds in ammonia, in which medium they behave as salts, are excellent conductors of electricity, undergo metathetic reactions with other substances, and exhibit properties characteristic of salts dissolved in water. Studies of these solutions have yielded many important results concerning the nature of metallic compounds.

Early in his career Kraus became interested in the properties of free groups. In this field he has studied the triphenyl methyl, alkyl-mercury, substituted ammonium, trimethyl tin, dimethyl tin, calcium hexammonate groups and several others. In connection with these groups many problems developed relative to the chemistry of organic compounds of metals, particularly of the third and fourth groups of the periodic table. Thus it is not surprising that, in the autumn of 1922, he was called upon to find a method for the preparation of lead tetraethyl which would be feasible on a large-scale production. After a few months' work he found success in the reaction which proceeds between NaPb and ethyl chloride at a relatively low temperature and pressure. The process used to-day in industry is essentially the same.

The chemistry of solutions of metals in liquid ammonia represents another phase of the field which has occupied Kraus' attention. He had predicted earlier that these solutions should serve as excellent reducing agents, since they give in ammonia the normal alkali metal ion and the ammonated electron, the latter being available to any group or atom which might have the slightest tendency to acquire it. The formation of metallic compounds represents one example of this type of reaction in ammonia. He continued these studies to include the reduction of many types of organic, metallo-organic and inorganic compounds, and some of the metallic and non-metallic elements.

Kraus has always been keenly interested in the electrical properties of solutions, particularly of non-aqueous solutions. He has carried out a great deal of work relative to the conductivity of substances dissolved in liquid ammonia, liquid bromine, acetone, isopropyl alcohol, dioxane, benzene and other solvents. In addition, he has investigated the conductivity of solid metallic compounds, alloys and glass. In 1922 he described the investigations of this field in the publication of an American Chemical Society Monograph entitled "The Properties of Electrically Conducting Systems." During the past few years his interest in this field has been directed chiefly to solvents of low dielectric constants and solutes consisting of large ions. This work is surely to be regarded as one of the most important contributions Kraus has made to our knowledge of electrolytic solutions.

Kraus left the Massachusetts Institute of Technology in 1914 to become director of chemical research at Clark University. After a stay of ten years here he moved to Brown University to occupy a similar position. To date he has contributed more than 100 articles in the fields mentioned above. In addition, he is credited with several patents dealing with the construction of graded glass seals, electrode seals, metal-glass seals, mercury vapor pumps and rectifiers. In 1923, he was awarded the Nichols Medal by the New York Section of the American Chemical Society for his work with nonaqueous solutions.

WARREN C. JOHNSON
DEPARTMENT OF CHEMISTRY,
UNIVERSITY OF CHICAGO

THE NEW MEDICAL BUILDINGS AT YALE UNIVERSITY

As the result of progress in a building program started fifteen years ago, the Yale University School of Medicine and the New Haven Hospital are now housed in a group of modern buildings uniform in architectural style and designed especially to facilitate the work of teaching, research and care of patients. In the group is included the Institute of Human Relations.

The buildings are of red brick with white stone trimmings, in a simple modified Georgian style. The first consideration has been to provide a maximum of space, air and light in well-coordinated teaching, research and clinical units. Ornamentation has been minimized, although the group as a whole is pleasing to the eye because of a unity attained by the arrangement of the massive structures.

There are approximately 14 million cubic feet of space in the group and the total cost of construction, with equipment, has been about $12,000,000, practically all of which has been provided specifically for the purpose by friends of the university. There are still a few old buildings to be replaced and new units to be provided, but the scheme as outlined some years ago has practically been realized. The group covers two city blocks, an area roughly one thousand feet square, divided by Cedar Street into two sections.

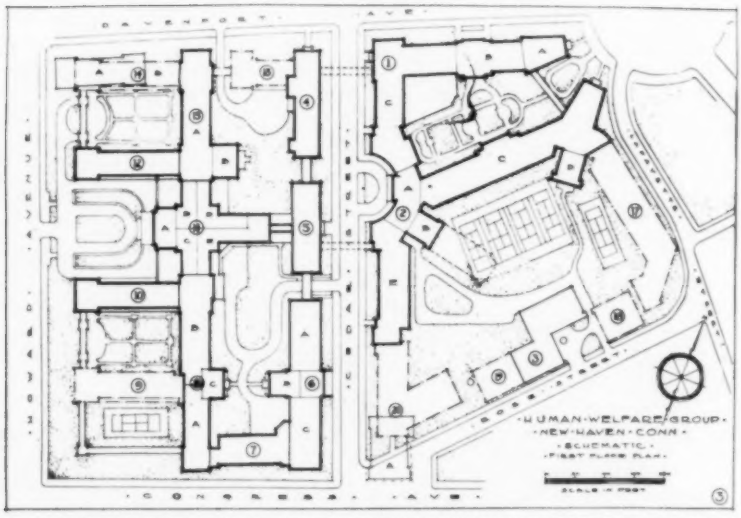
The units containing the preclinical science departments are located on the east side of Cedar Street. Laboratories of anatomy, physiology, physiological chemistry, pharmacology and psychobiology are contained in the Sterling Hall of Medicine. Articulated with this building is the Institute of Human Relations, containing clinical facilities of the department of psychiatry and mental hygiene, laboratories of psychology and physiological psychology, Clinic of Child Development and anthropology and social science research units. The Sterling Hall of Medicine also contains the library of the School of Medicine, amphitheater, administrative offices and recreational facilities, including lounge, gymnasium and squash courts. The institute building has a lounge and a dining room for staff members.

The buildings of the New Haven Hospital and of the clinical divisions of the School of Medicine are on the west side of Cedar Street, connected by underground passages with the Sterling Hall of Medicine and the institute. Heating and lighting are provided by a central power plant, and maintenance services of all buildings in the group are coordinated. The clinic building constitutes the center of the clinical division of the group. Patients for the hospital and dispensary all enter here and are directed by way of inside corridors and elevators to the various clinics and wards. The clinic building houses not only central administrative offices, including information, business and admitting services, pharmacy and x-ray units and social service, but also central kitchens, dining rooms and supply service.

A transverse section, extending north and south from the clinic building, contains laboratories, offices, examining rooms, seminar and classrooms for the departments of medicine, pediatrics, surgery and obstetrics and gynecology. Pavilions for patients extend to the west at right angles with the laboratory units. Two new pavilions, the Raleigh Fitkin Memorial for medicine and pediatrics and the Sarah Wey Tompkins Memorial for surgery and obstetrics, are both six stories in height. Each of the five ward floors in each pavilion contain about twenty-six beds, ten of them in single rooms and the remainder in two-, four- and six-bed rooms. The ground floors contain the outpatient examining and treatment rooms. The Isolation Pavilion is an older structure, which will ultimately be replaced by a pavilion similar to the new ones.

ENTRANCE TO THE STERLING HALL OF MEDICINE AND THE INSTITUTE OF HUMAN RELATIONS

ENTRANCE TO THE CLINIC BUILDING OF THE NEW HAVEN HOSPITAL SHOWING THE RALEIGH FITKIN MEMORIAL PAVILION ON THE LEFT AND THE SARAH WEY TOMPKINS PAVILION ON THE RIGHT.



A PLAN OF THE BUILDINGS IN THE HUMAN WELFARE GROUP

(1) Institute of Human Relations. (2) Sterling Hall of Medicine. (3) Power House. (4) Private Patients Pavilion. (5) Boardman Administration Building. (6) Brady Memorial Laboratory Building. (7) Lauder Hall. (8) Farnam Memorial Building. (9) Future Ward Unit "A." (10) Sarah Wey Tompkins Memorial. (11) Clinic and Service Building. (12) Raleigh Fitkin Memorial. (13) Medical and Pediatric Laboratory. (14) A. Existing Isolation Pavilion. (1) B. Future Isolation Ward "D." (15) Future Private Pavilion Addition. (17), (18), (19), 20. Future Buildings. 20. A. Existing New Haven Dispensary.

Operating rooms are on the top floor of Farnam Memorial Building, the section housing the departments of surgery and obstetrics and gynecology. This section, like the section for medicine and pediatrics, has an amphitheater. The departments of bacteriology, pathology and public health occupy the Brady Laboratory and Lauder Hall, fronting on Cedar Street. The Boardman Memorial Building, containing offices and classrooms of the School of Nursing and the private pavilion, also front on Cedar Street. All construction is on the unit basis, with all units interconnecting and with a minimum amount of fixed equipment. This allows for easy contraction and expansion of all units to meet current needs, an economical arrangement, since it is impossible to predict departmental developments which will take place from time to time.

The scheme of the buildings is in accord with the general policy of the school to coordinate the activities of its many departments and to function educationally as a unit as far as possible. Wards, outpatient clinics, research laboratories, offices and amphitheaters associated with each service are adjoined vertically or horizontally, related services, such as surgery and obstetrics and gynecology on the one hand, and medicine and pediatrics on the other, are located next to each other, and general services for the use of many departments, such as x-ray, pharmacy, social service and admitting offices, are centrally located so that they will be nearly equidistant from all the sections which they serve.

Although the success of a School of Medicine, or any other human institution, is measured by the quality of its product and not by its buildings, Yale has acted on the theory that well-planned physical facilities constitute an important asset in medical teaching and research if they can be provided, as they have been at Yale, without detriment to teaching and research budgets.

H. H. L.